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Canotia is named for *Canotia holacantha* Torr. (Celastraceae), a spiny shrub or small tree nearly endemic to Arizona. Cover illustration by Alandon Joe.

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VEGETATION CHANGE AND FLORISTIC INVENTORY OF CIENEGA CREEK NATURAL PRESERVE, PIMA COUNTY, ARIZONA

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ABSTRACT: The Cienega Creek Natural Preserve lies at the eastern edge of the Sonoran Desert near Tucson, Arizona. I documented the plant diversity of this protected area across 35 years with herbarium collections and photographic vouchers made between 1986 and 2021. I conducted intensive floristic surveys between 2013-2019 and remapped vegetation communities during a period of increasing aridity. Over 500 species of vascular plants occur in this 1726-hectare area. A variety of rock types and geomorphic surfaces, as well as riverine connections to adjoining sky-island mountain ranges, contribute to plant diversity. Many areas that were mechanically disturbed and heavily grazed have naturally revegetated since 1986, and the ephemeral channel has narrowed, particularly from growth of the burrobrush (*Ambrosia monogyra)* and Fremont cottonwood (*Populus fremontii)* plant associations. Around 50 species seen in wetter years or at the beginning of prolonged drought were not found during the intensive collection period. Several exotic species have colonized or expanded their distributions over the past 20 years. Cottonwood and Goodding willow (*Salix gooddingii*) seedlings are not recruiting under current conditions, and some mature cottonwoods have died. Mesquite forests stranded on incised Holocene terraces show severe canopy dieback, even as young mesquite, Arizona walnut (*Juglans major*), and velvet ash (*Fraxinus velutina*) establish and mature on floodplains and low terraces.

INTRODUCTION

The Cienega Creek Natural Preserve (Preserve) is situated in southeastern Arizona, along a natural east-west passageway between the Sonoran Desert of the Tucson Basin and the semi-desert grasslands of southeastern Arizona (Figure 1). Here, a protected area of 1726 ha (4267 ac) or 17.3 km^2 (6.7 mi^2) was established in 1986 by the Pima County Board of Directors along 19 km (12 mi) of valley bottom, protecting one of the few remaining perennial streams for future generations (Figure 1).

The Preserve is part of a larger conserved landscape under Pima County's Multi-species Conservation Plan, and provides mitigation for species impacts under an incidental take permit issued by U.S. Fish and Wildlife Service. Cienega Creek facilitates wildlife movements to and from various surrounding mountain ranges, maintains a natural floodplain and water supply, and provides habitat for a number of federally protected species of wildlife, including native fish.

Based on models using tree-ring data, southwestern North America is experiencing the lowest soil-moisture conditions in over 1000 years (Williams et al. 2022). Mass die-offs of broadleafed riparian trees in our area occurred in 2005 along the Santa Cruz River in Santa

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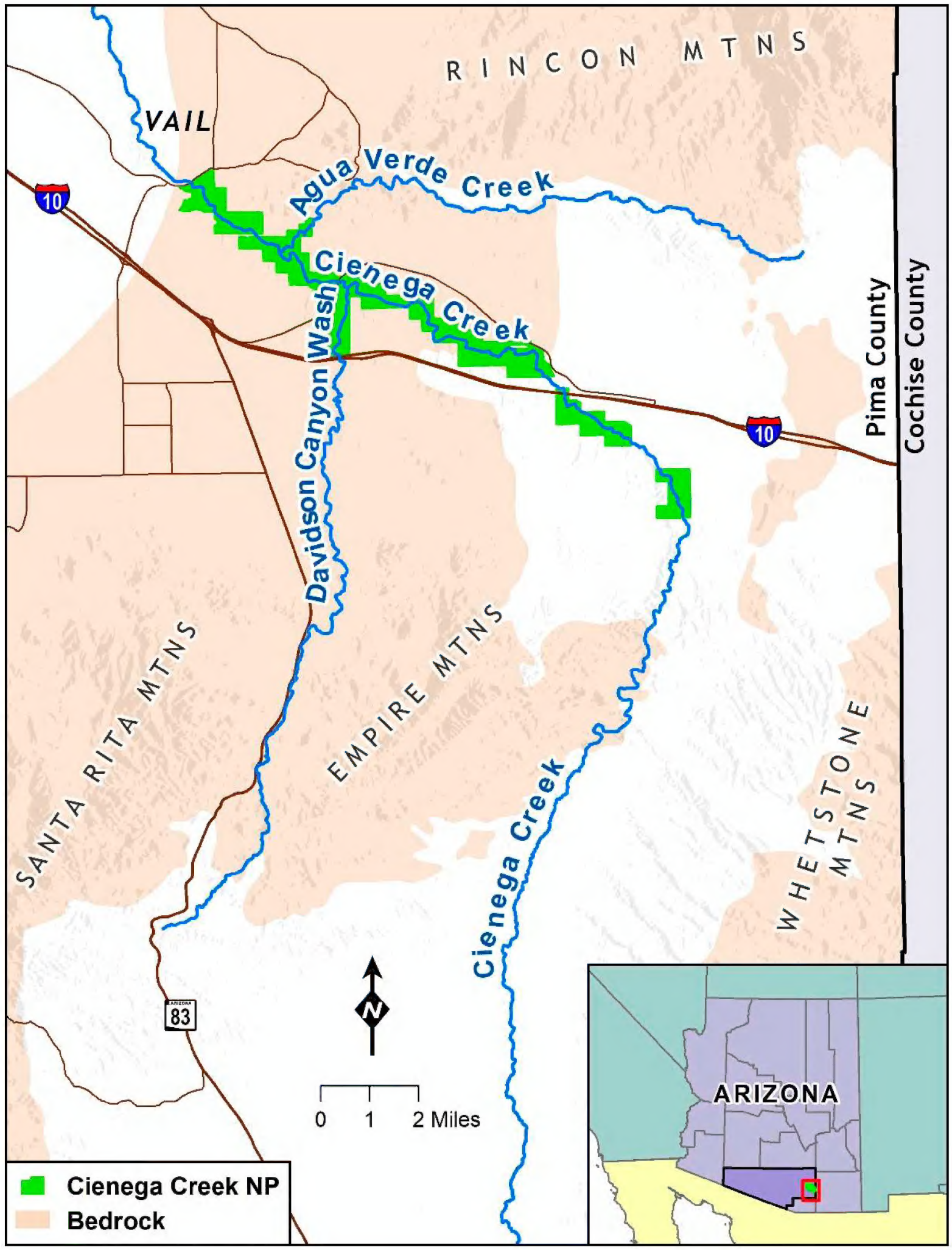

Figure 1. Location of Cienega Creek Natural Preserve in Pima County, Arizona, showing Cienega Creek and its principal tributaries. Map by Mike List, Pima County.

Cruz County (Sonoran Institute, n.d.), and at Bingham Cienega and the San Pedro River in eastern Pima County in 2013 (personal observation, June 28, 2013).

This study uses observations of changes in plant life over time, combined with remapping of vegetation communities to provide a basis for considering what additional changes in floral composition and distribution of vegetation might occur in the Preserve under a warming climate.

STUDY AREA

Cienega Creek receives runoff from mountain and valley terrain typical of the Basin and Range Province of southeastern Arizona. Elevations in the Preserve range from 953 m (3128 ft) above mean sea level in the western part of the Preserve, to a maximum of 1213 m (3980 ft) south of U.S. Interstate 10 (I-10) at the eastern limit of the Preserve.

My first trip to the area was in 1986, as part of the first purchase of land by Pima County Regional Flood Control District (District). The land was purchased from a prominent local rancher and I was entrusted with its protection.

Cienega Creek has, like many other valley-bottom streams in the Southwest, seen its share of plant community change since the late 1800s: loss of upland grasslands, incision of the channel, and draining of the marshy lands that gave names to the area. The name of Cienega Creek changes to Pantano Wash just upstream of Vail, Arizona. In Spanish, both *ciénega* and *pantano* can refer to graminoid-dominated wetlands that occurred in mid-elevation valley bottoms in southern Arizona, New Mexico, and northern Sonora and Chihuahua (Hendrickson & Minckley 1984). No cienegas remain in the Preserve today, although the watershed above it retains a number of such wetlands.

The extent of base flows has declined to as little as one-tenth of what it was in 1986, and has provoked alarm regarding the loss of aquatic habitat for native fish and other wildlife in an increasingly hot and arid climate. All of these changes motivated my interest in documenting the flora of the Preserve. Closer examination of the floristic diversity of this area at the eastern edge of the Sonoran desert may reveal the outline of potential and future vegetation community shifts due to changes in climate and land use.

Objectives for this paper are:

1. Describe the setting of the Preserve in terms of, geology, climate, hydrology, and land use.
2. Characterize the vascular plant diversity of the Preserve.
3. Describe the current distribution of plants and plant communities in relation to land-use history and landscape position.
4. Document changes in vegetation communities and plant species since 1986.
5. Discuss potential futures for vegetation communities and species.

METHODS

This study is based on observations during field work and herbarium specimens collected after 1986, supplemented by remapping of vegetation communities from high-resolution imagery.

Previous Floristic Work

The study area lies within an area of the state that is well-collected due to its proximity to Tucson and regional herbaria. Plant collection began with topographical surveys in the 1870s and itinerant botanists in the 1880s, then continued sporadically into the early 1900s. Few specimens were collected during the rest of the twentieth century. Specimens before 1986 were not considered part of this flora due to the profound changes in the upland and riparian vegetation communities that occurred in the early twentieth century.

Smith and Unangst (1987) prepared an initial plant list upon establishment of the Preserve in 1986. Their list inspired me to add more plant observations. The working list grew to over 200 species and formed an initial basis for what I might expect to collect during field surveys. This list and my field notes (1986 to 2021) informed the present evaluation of floristic and plant community changes that have occurred since the Preserve was established.

I commissioned several plant-related studies during my tenure as preserve manager for this area: McGann & Associates (1994), Titus (2001), Pima Association of Government (2002, 2003) and Sage Landscape (2005). No herbarium collections were made and few photographs were taken as part of those studies. Only one photograph voucher from these sources is referenced in this study. Juliet Stromberg and her students also worked in the Preserve (Stromberg et al. 2009; Katz et al. 2011) and made collections. A number of their collections are used as vouchers herein.

I reviewed herbarium records from the surrounding area through Southwest Environmental Information Network (SEINet) to compile a list of potentially extant species that I carried in the field. SEINet is an online repository for regional plant collections and other records, allowing access to the databases of regional herbaria. All or nearly all Arizona plant collections at Arizona State University (ASU) and University of Arizona (ARIZ) herbaria have been entered into SEINet.

Jillian Cowles photographed plants during 2004–2009 near the Agua Verde confluence. For this study, I entered photographic vouchers of plants she found in the Preserve into SEINet, and used her photographs with permission. For locations of photographs provided by Jillian Cowles, I referred to Pima County digital orthophotography in combination with verbal descriptions from Cowles and an index map maintained by Cowles. Most of Cowles' photographs had been previously identified by curator Phil Jenkins or others at the University of Arizona Herbarium (Cowles, personal communication), but I made a few corrections.

Field Methods

I searched the Preserve to add or confirm presence of species approximately three to four hours by foot, nearly every month, often with one or two companions from Arizona Native Plant Society, beginning February 2013 and continuing through 2016. In 2017, I stopped monthly searches in favor of the productive spring and fall seasons. Systematic collection for this project ended May 2019, with only a few incidental collections in 2020 and 2021. I tried to collect voucher specimens of most taxa (excluding succulents) even if they were already

collected and vouchered after 1986. To evaluate the completeness of my flora, I constructed a species accumulation curve for specimens I collected since February 2013.

Searches included a wide variety of areas such as tributary stream beds, disturbed areas, different geomorphic surfaces, and unique geologic substrates. My volunteers and I contributed 402 person-hours in the field through May 2019; time spent in identifying and preparing specimens was not measured but easily equaled the field time. The vast majority of the collection and identification effort was conducted as a permitted volunteer for Pima County Natural Resources, Parks and Recreation, separate from my work at Pima County.

Locations and elevations were usually determined using a handheld Garmin GPS during the collection. Some locations were determined after collection using Pima County's high resolution digital orthophotography for reference. Notes for most plant collections usually include substrate, landscape position, associated plants, shading, evidence of historical land disturbance, and whether the plant was in water or moist soils.

I used photographic vouchers for most cacti and agave, and for a few additional species reliably photographed between1986 and the start of 2013 field surveys. These are associated to field data and vouchers in SEINet and referenced in individual plant profiles (Appendix A). Descriptions in Appendix A may include notes regarding change in abundance or recruitment over time, based on past field notes.

Herbarium Methods

I identified plants listed in Appendix A with assistance from the staff and volunteers at University of Arizona Herbarium. If a variety or subspecies is not listed, then it was not identified to the infraspecific level.

The main keys I used were Kearney and Peebles (1960) and for dicots, various contributions to Vascular Plants of Arizona (Editorial Committee 1992). For grasses, I also referenced Gould (1977) and Allred and Ivey (2012).

All specimens were accessioned at University of Arizona's herbarium (ARIZ) unless otherwise noted by standard herbarium abbreviations as used in SEINet. Duplicates were sometimes provided to the herbarium at Arizona State University (ASU). Most label information is available through a research checklist I prepared in SEINet for the Cienega Creek Natural Preserve, including annotations on vouchered specimens. Access to research checklists is provided through the "Flora Projects" tab. The plant profiles in Appendix A have additional background on distribution or history of occurrence in the Preserve.

Voucher specimens previously collected by others were verified by inspection at herbaria located at ARIZ and ASU. I also noted in SEINet several misidentified locations assigned to previous records based on my knowledge of place names.

Plant nomenclature follows Tropicos (2022) or failing that, USDA Plant Names (2022). Plant nativity for the United States is based primarily on the information provided through SEINet and USDA Plant Database.

The wetland indicator status of a plant species is used to ascertain the number of wetland species that may no longer be present. The classification follows U.S. Army Corps (2020) regional list for the Arid Southwest, and qualitatively indicates the likelihood that a plant occurs in wetlands.

Vegetation Methods

I reviewed stereophotography, contact prints and digital imagery in the possession of Pima County and its Regional Flood Control District dating back to 1936 to gain a sense of the historical trajectory of vegetation communities and water availability in the Preserve (Fonseca 1993). I also summarized the content of my field notes with respect to vegetation changes for the period 1986-2012.

To identify change in riparian vegetation communities within the preserve for the present study, I remapped the boundaries of some existing fine-scale map units originally prepared by Dr. Margaret Livingston of McGann & Associates (1994). The map units utilize the sixth-order vegetation associations of Brown (1994: Tables 6 and 7).

As a basis for modifying the map units, Elisabeth Van Der Leeuw at Pima County Information Technology resampled 2-foot (0.6 m) four-band (blue, red, green, infrared) June 2019 National Agricultural Inventory Project imagery to 10-foot (3 m) resolution. Then we used 3-inch (7.6 cm) resolution 2020 Pictometry imagery to select training polygons for supervised classification of reflectance associated with dominance by creosote (*Larrea tridentata*), grass, mesquite (*Prosopis velutina*), burrobrush (*Ambrosia monogyra*), burroweed (*Isocoma tenuisecta*), or cottonwood (*Populus fremontii*), as well as bedrock and open channel sediment.

Using the results of the supervised classification and natural-color 2019 and 2020 imagery, along with my field knowledge and point observations associated with plant collections, I updated and refined the vegetation association boundaries. I separated McGann and Associates' Bedrock and Sparsely Vegetated Channel unit into two categories based on the supervised classification, and mapped three new vegetation associations. I realigned units based on improved imagery registration with Preserve boundaries, and mapped new areas that have been acquired and incorporated into the Preserve. I occasionally extended the upland classification to small, dry valleys tributary to Cienega Creek, where there was little basis for identifying a separate riparian vegetation community.

GEOLOGIC AND GEOMORPHIC SETTING

The Preserve is situated in the Cienega Gap as defined by Brennan (1962), an area of low-lying bedrock exposed between the Rincon Mountains to the north, and the Santa Rita and Empire Mountains to the south (Figure 1). Elevations in the Preserve range from 953 m (3128 feet) to 1213 m (3980 feet). Bedrock in the Preserve was transported 18–20 km (11–12 mi) southwest relative to the Precambrian granites of the Rincon Mountains during a period of mid-late Tertiary tectonic extension (Richard & Harris 1996).

Four main geological units in the Preserve have significance to plant life: unconsolidated recent alluvium, older (Pleistocene to late Tertiary) basin-fill alluvium, the mid-Tertiary Pantano Formation, and a pre-Tertiary bedrock complex. Bedrock ranges from Precambrian schist and granites to Permian and Pennsylvanian limestone and andesite. The

Pantano Formation in the Preserve varies from a cemented mudstone with interbedded clays to a conglomerate (Drewes1977).

South of I-10, the alluvial basin is deep and broad and the stream is ephemeral. North of I-10, bedrock outcrops constrict the alluvial deposits, and groundwater discharges to the surface. Groundwater is yielded to the stream primarily from geologically recent alluvial deposits, although in some areas in and around the Preserve, small amounts of groundwater come through the gypsiferous Pantano Formation, which underlies recent alluvium in many places. In the study area, the recent alluvium receives recharge from the infiltrating stormflows, and receives discharges from the basin-fill deposits and slow leakage from the Pantano Formation (Montgomery & Associates 1985).

Multiple cycles of floodplain development and streambed incision have shaped the valley (Eddy & Cooley 1983), creating a series of high terraces, with Pleistocene terraces cut into coarse-grained basin fill and bedrock units. Soils formed on the Pleistocene terrace have an orangey color and some clay. The most recent incision along Cienega Creek began shortly after the initial construction of the Southern Pacific Railroad in 1880. Most of the creek is bordered by a Holocene fill terrace consisting of brown, predominantly fine-grained alluvium that was historically saturated prior to the downcutting that began in the 1880s (Fonseca 1993; Figure 2). In some cases, the downcutting exposed bedrock outcrops.

CLIMATE AND HYDROLOGY

The climate is warm and semi-arid. The minimum January temperature is estimated to vary from -0.8°–5° C (30°–41° F) (Figure 3). This has ecological significance because freezing temperatures can influence the distribution of frost-sensitive plant species as well as the growing season length. Former residents in the Preserve note that winter low temperatures are more severe along the stream bottom than in adjacent uplands (Neal and Diane Hanna, personal communication, 2013) and I can attest to cold-air drainage. Mean July temperatures were generally below the long-term average (82.4° F, 28° C) in the 1980s and early 1990s, and have been generally above the long-term average since the mid-1990s (Figure 4). This is a factor which increases rates of evapotranspiration.

Rainfall occurs primarily in late winter and late summer. Occasionally, tropical storms in September and October can bring heavy, multi-day rainfalls, such as those that provoked the 1983 flood. The proportions received during winter and summer months vary widely, but long-term records suggest around 62.5% of the annual rainfall in the watershed occurred during the summer season (Huckell 1995). More recent analyses show that winter precipitation has decreased since 1981, with significant declines in the late 1990s and between 2001—2006 (Murray et al. 2022).

Annual precipitation as modeled would be around 39 cm (15.5 inches) based on a twenty-year average as shown in Figure 5. Based on nine rain gauges located within and near the Preserve, the Preserve received an average of only 26 cm (10 in) of rain per year during the past 20 years (Pima County 2021). Actual rainfall is temporally and spatially variable. Annual rainfall based on individual gauges within and near the Preserve has varied from a low of 8 cm (3 in) in 2020 to a high of 61 cm (24 in) in 2021 (Pima County 2022a). In 2020, one

gauge in the Preserve received 30 cm (12 in), while the overall average of nine rain gauges was 14 cm (5.5 in). The overall average for 2020 was 13 cm (5 in) less than the 20-year average.

During 2013–2019 when I collected most of the plant specimens, rainfall was scant (Figure 5). The relative paucity of rainfall should be taken into consideration when understanding the abundances of particular species noted in this study. Prolonged, severe drought conditions began in 2002 and continued during the period of plant collection, except for rainfall in spring 2019. This is well illustrated by a yearly precipitation-evapotranspiration index, emphasizing the influence of higher-than-average temperatures on long-term water balance (Figure 6).

Figure 2. Contact between Holocene fill terrace and older basin fill unit exposed by post-1880 arroyo incision along Cienega Cree. Goodding willow (*Salix gooddingii*) in the foreground. cottonwoods (*Populus fremontii*) in the background. Mesquite (*Prosopis velutina*) will be found on top of the Holocene fill terrace as well as in the floodplain. 2013 photograph by Brian Powell, Pima County.

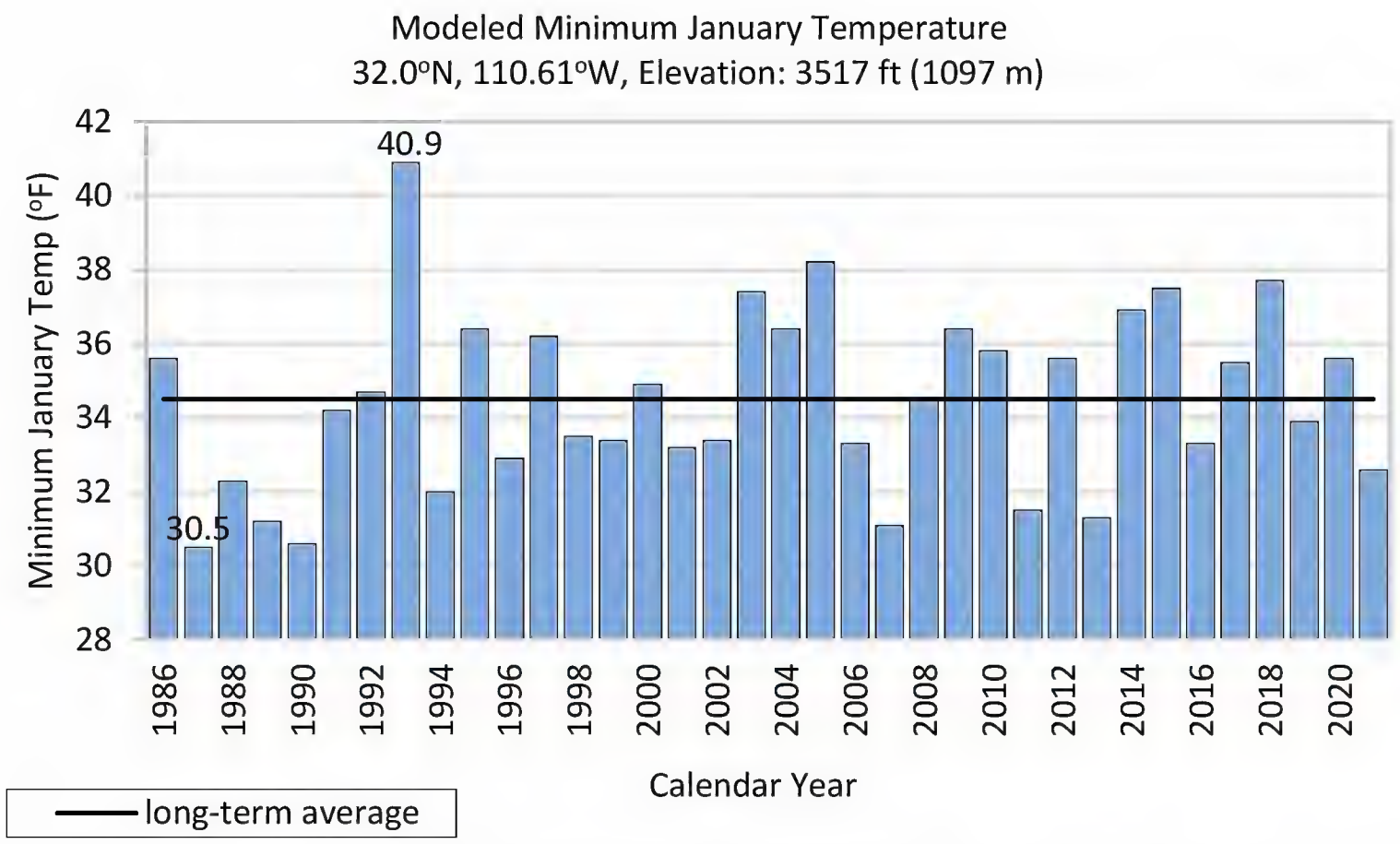

Figure 3. Minimum January temperatures for the Cienega Creek Natural Preserve from 1986-2021, based on 4-km PRISM model. Data source: www.prism.oregonstate.edu

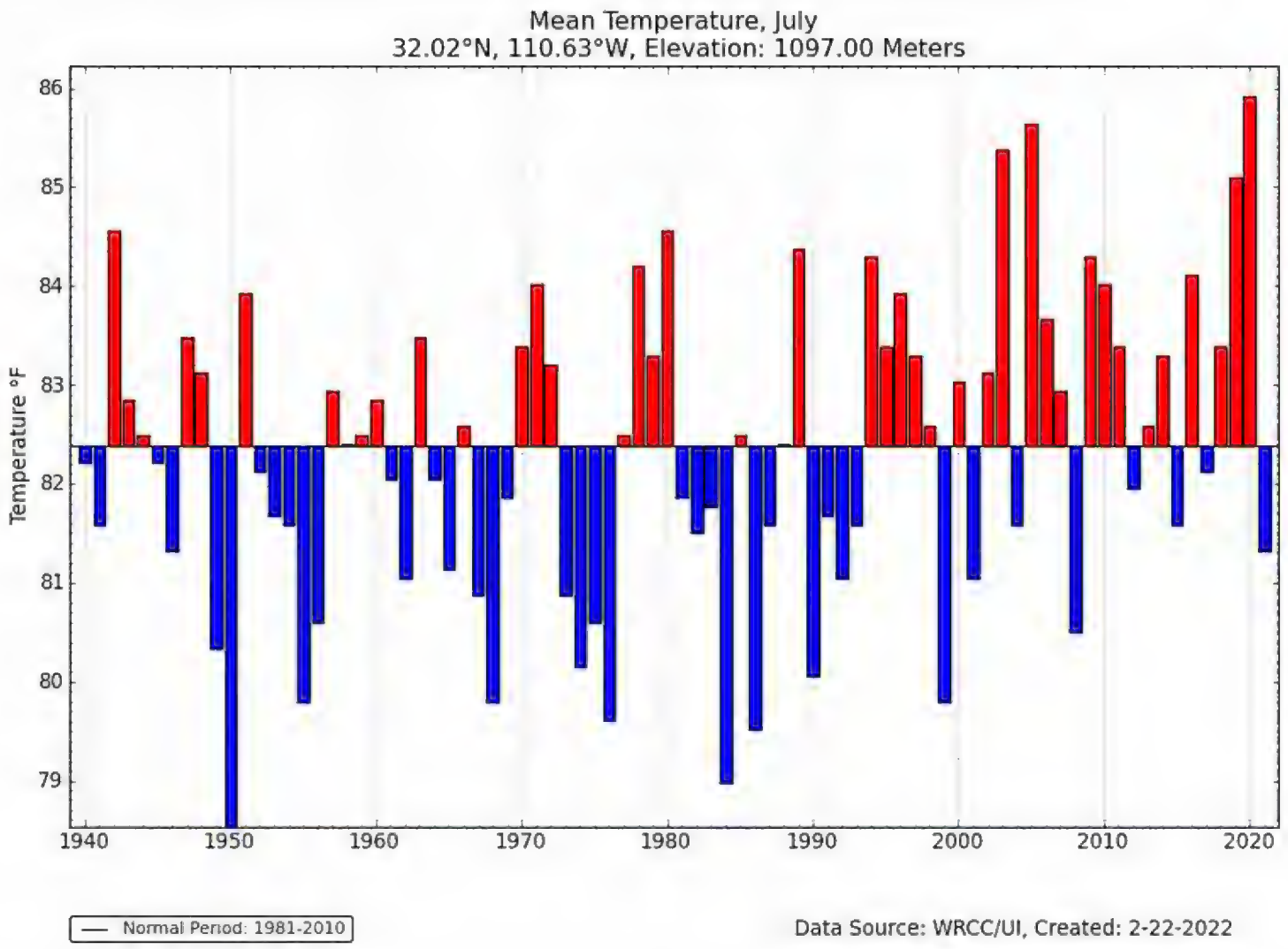

Figure 4. Mean July temperatures for the Cienega Creek Natural Preserve from 1940-2021, plotted to emphasize difference from long-term average of 82.4° F. July mean temperatures prior to 1995 were cooler than afterwards.

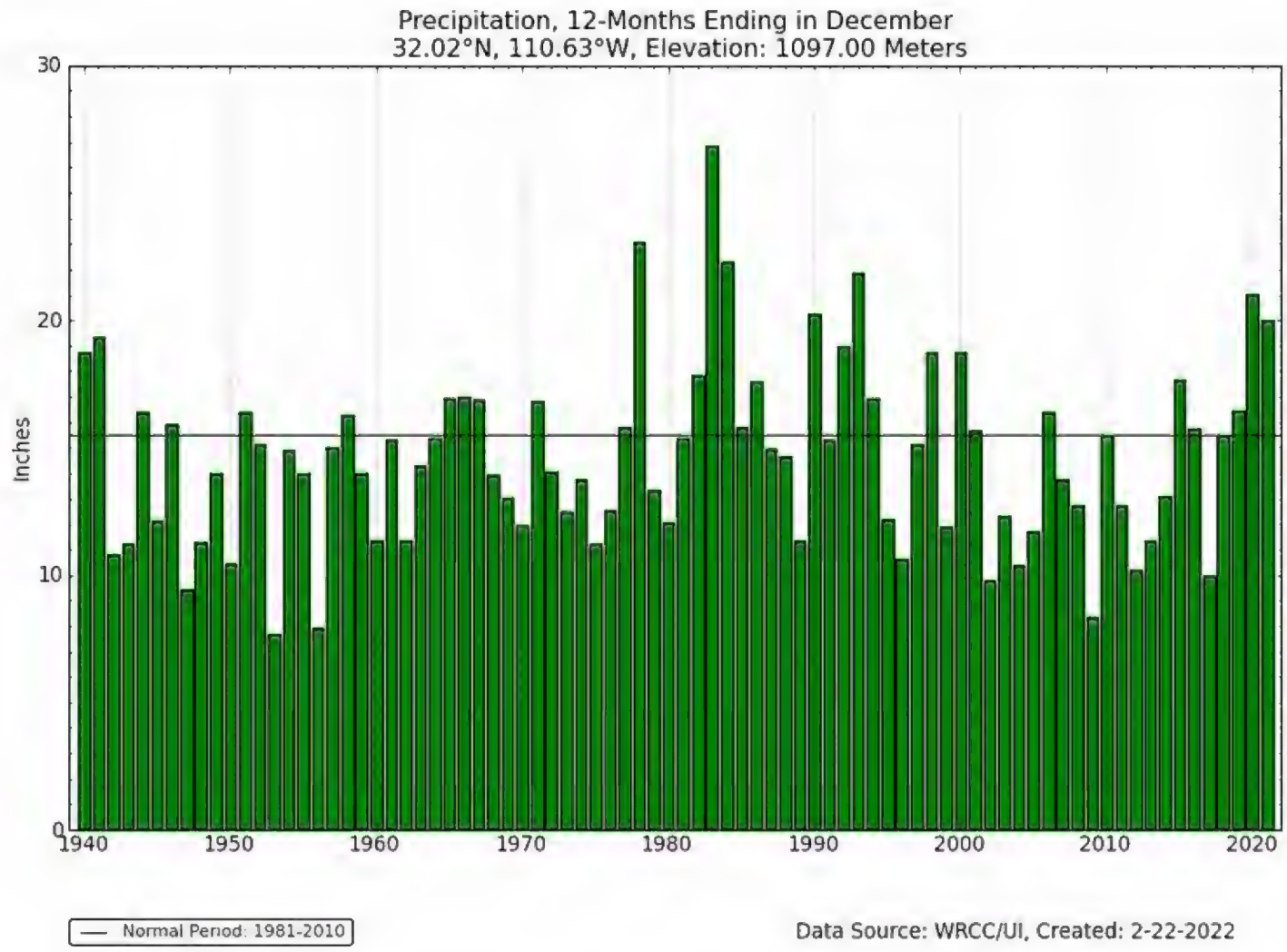

Figure 5. Annual precipitation for vicinity of Cienega Creek Natural Preserve from 1940-2021, with average of 15.5 inches indicated for period of 1981-2010.

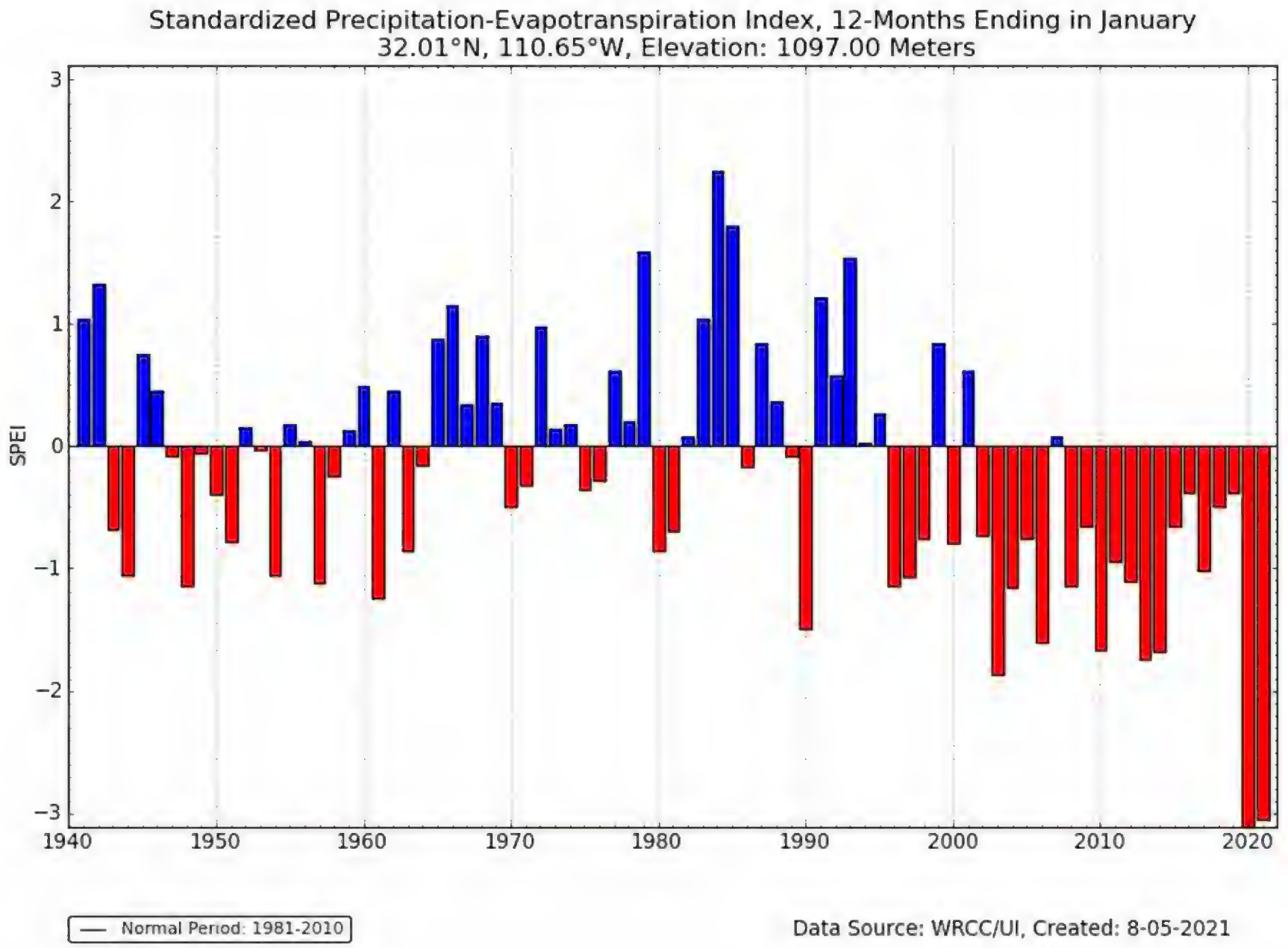

Figure 6. Yearly values of the Standardized Precipitation-Evapotranspiration Index (SPEI), a measure of meteorological drought conditions, for the vicinity of Cienega Creek Natural Preserve from 1940–2021. Note the persistent drought that began after 2000. An SPEI value of zero (0) represents "normal" conditions where the probability of drought vs. non-drought conditions is equal by definition; negative values reflect greater probability of drought (vs. normal) conditions and suggest their relative severity (Serrano et al. 2010).

In 1986, 12.8 km (8 mi) of stream flowed throughout the year (Figure 7). By summer 2000, only 4.5 km (2.8 mi) ran year-round, and by June 2012, less than 1.6 km (1 mi) (PAG 2011). Shallow groundwater levels in alluvium near Cienega Creek declined after 2002; an exceptionally wet summer in 2021 seems to have reversed the trend (Pima County 2022a).

Baseflows on Cienega Creek are small, generally less than 0.03 cubic meters per second (1.06 ft^3/s) (Figure 8), and these are sustained by discharges from the aquifer, while storm flows result from precipitation and runoff (Fonseca 1993, Powell et al. 2015).

The watershed is approximately 1184 km^2 (457 mi^2) in size at the lower end of the Preserve. The watershed is capable of producing large flood events but before and during this study flood peaks were generally quite small, under 28 m^3/s (1000 cfs). These occurred principally during July through September. The largest peak flow since 2008 occurred in July

23, 2017, with a discharge of 261.4 m^3/s (9,230 ft^3/s). An even larger flow of 444.6 m^3/s (15,700 ft^3/s) occurred on July 23, 2021, after plant collection had largely ceased (Figure 8).

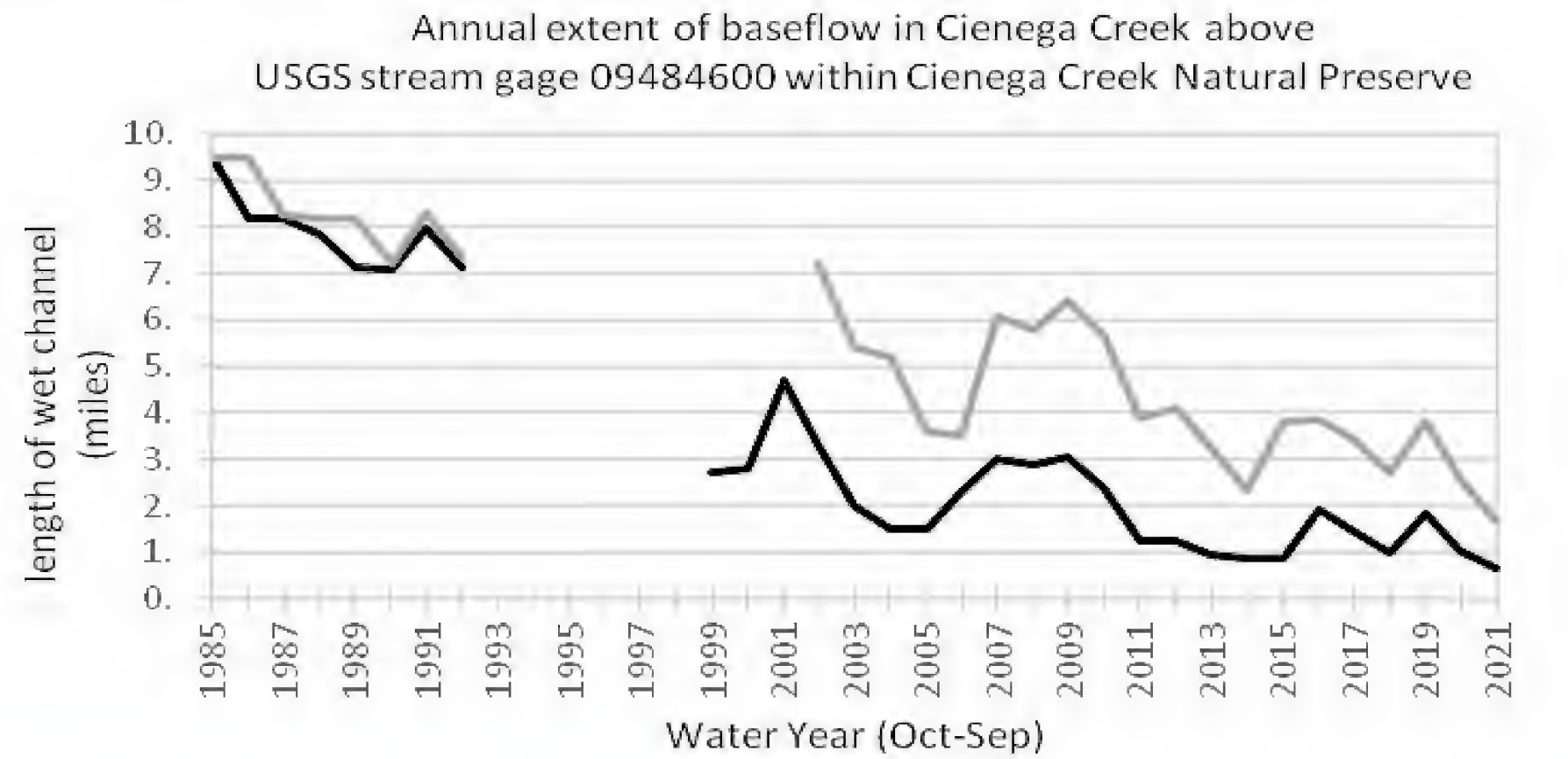

Figure 6. Extent of baseflow within the Cienega Creek Natural Preserve based on quarterly surveys during water years 1985–2021: black line represents minimum length of wet channel observed during any one of the four annual surveys; gray line represents maximum length of wet channel during the water year. Water years run from October 1 to September 30 of the following year. Data provided by Melanie Alvarez, Pima Association of Governments.

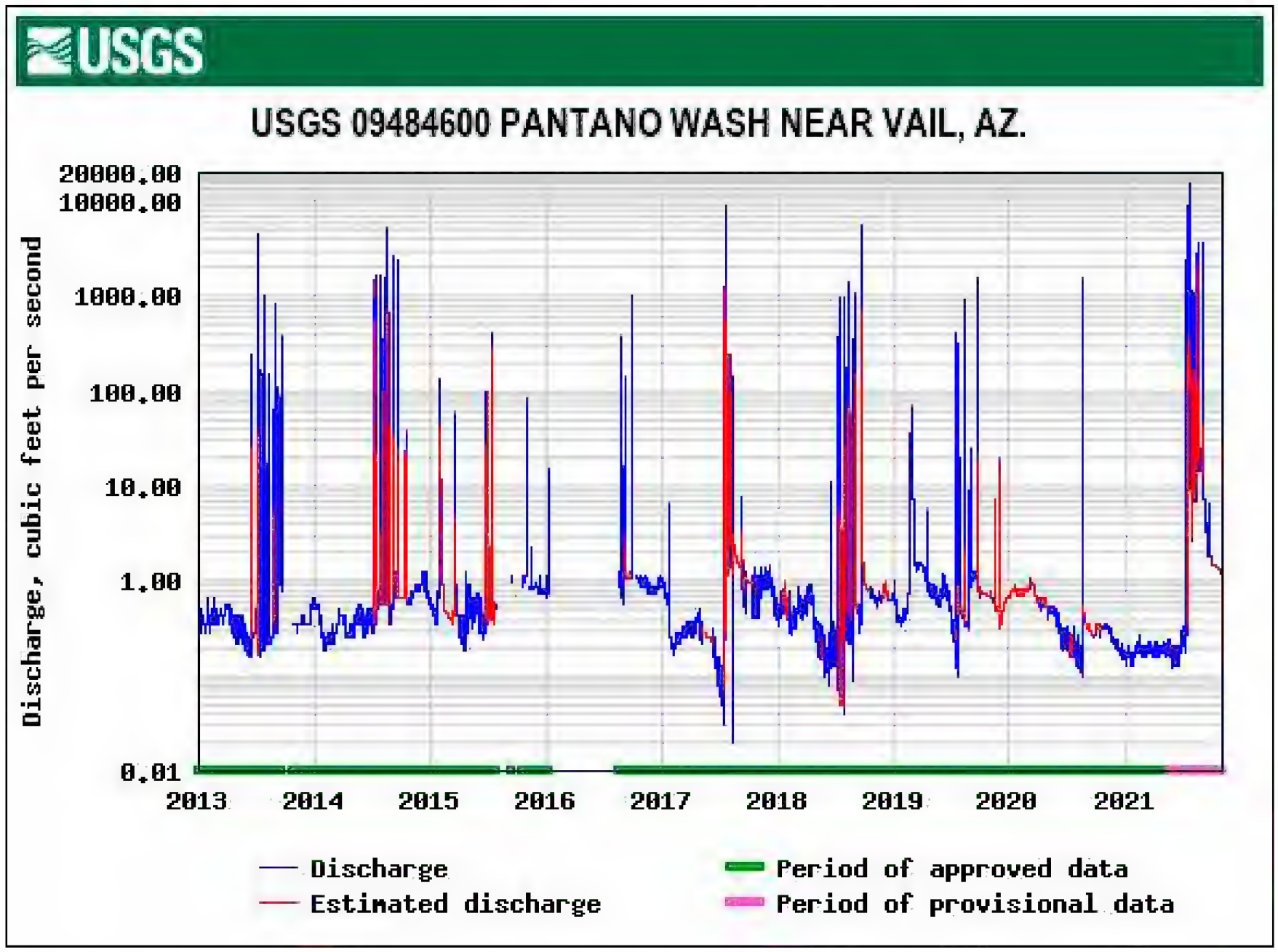

Figure 7. Daily discharge of Cienega Creek (Pantano Wash) at a stream gauge located in the Cienega Creek Natural Preserve. Between 2013–2021, baseflows were usually below 1 cubic foot per second (0.03 m^3/s). Most flood flows were small, but an exceptionally large flood occurred July 2021. Source: U.S. Geological Survey stream gauge 09484600.

This last flow was the largest flow since 1958; it removed much of the channel vegetation and elevated base flows once again.

LAND USE HISTORY

Known to the Spanish as *Ciénega de los Pimas*, these lands are ancestral to Sobaipuri, Tohono O'odham, and later Apache peoples. Archaeological evidence suggests the Cienega Creek floodplain was used for some of the earliest indigenous maize-based agriculture in the U.S., prior to adoption of ceramic technology (Huckell 1995). Human occupation of the floodplain continued for thousands of years despite periodic entrenchments of the channel (Eddy & Cooley 1983, Hemmings et al. 1968, Huckell 1995). Maize-based floodplain agriculture continued by Hispanic and Anglo settlers after suppression of the Apache (Hemmings et al. 1968).

Historically, this part of Cienega Creek was characterized by marshes and grasslands with year-round water (Hendrickson & Minckley 1984), and served as a passage for movement between the Tucson and San Pedro basins.

A "picket post" was reportedly established by the U.S. Army in 1868 at Cienega de los Pimas, 30 miles east of Camp Lowell. According to Charles Smart (1870, p. 464), the Post Surgeon at Camp Lowell:

> *The position selected was the highest point of the broken country in the vicinity of the cienega or marsh; this for reasons military as well as hygienic. A rude but commodious and weather-proof hut was built of cottonwood timbers....The ration here could be supplemented by hunting, as quail, duck and rabbits were plentiful in the neighborhood, and antelope was occasionally to be found on the mesa.... At both of these posts, the water supply was good from a running stream.*

A transcontinental railroad was constructed in the floodplain starting in 1880 (Figure 9a). Arroyo downcutting began the following year, incising giant sacaton (*Sporobolus wrightii*) bottomlands and cienegas (Smith 1910, Hendrickson & Minckley1984). The incision of the Holocene alluvial fill unit led to a lowering of the water table, as indicated by the elevation of present-day groundwater discharges that I compared to former stream locations shown in early surveys (Fonseca 1993). By 1936, velvet mesquite (*Prosopis velutina*) had come to dominate the former floodplains, now terraces, and the new channel had assumed dimensions and locations similar to modern conditions (Fonseca 1993; Figure 9b).

As the principal source of water for the surrounding region, the bottomlands were the focus of early livestock impacts. The Pantano townsite, located within the present-day Preserve, was a major railroad shipping point for livestock in the late 1800s for the Empire Ranch, roughly 26 miles (41 km.) to the south. The Pantano townsite was inhabited until the 1950s (McGann & Associates 1994).

A small subsurface dam was built across the channel in 1910 (Smith 1911) to divert base flows for downstream irrigation. This structure remains in place and the diverted flow irrigates a golf course in Vail. Off-channel livestock watering sources were gradually established throughout the 1950s and 1960s, and groundwater pumping for pasture irrigation increased in the 1970s.

Figure 9a. Historical view across Cienega Creek floodplain by C. E. Watkins, 1880 shortly after construction of a railroad in the floodplain. Note presence of mesquite (*Prosopis velutina*) and ocotillo (*Fouquieria splendens*) on the otherwise denuded hillside, and the predominantly grassland aspect of both the tributary and mainstem floodplains. Fence is of the type traditionally made of cut mesquite. Source: Huntington Library.

Figure 9b. Same location, January 24, 1998. Photograph by Raymond Turner. The hillside is a mix of mesquite (*Prosopis velutina*) and creosote (*Larrea tridentata*). The dark bottomland vegetation is predominantly mesquite, but large white trees are cottonwoods (*Populus fremontii*). Source: U.S. Geological Survey, Stake 3411.

Many of the terraces along both Cienega Creek and Davidson Canyon, a major tributary, were cleared of mesquite (*Prosopis velutina*) for pasture improvements in the 1960s and 1970s; some were also planted with non-native species and irrigated.

In 1988, following acquisition of the area by the District, grazing was reduced north of I-10; by 1992, this activity was largely eliminated and agricultural irrigation of pastures south of I-10 ended (Fonseca 1993). Horses grazed in a designated pasture at the Pantano Jungle site north of I-10 until 2010. Cattle continue to graze in part of the Preserve south of I-10, and there is occasional trespass of livestock into other parts of the Preserve.

Recreational use in the 1970s and 1980s primarily consisted of off-road vehicular use in the channels and night-time parties. Woodcutting was common until the late 1980s when off-duty sheriffs hired by the District reduced motor-vehicle access to the bottomlands. While illegal off-road vehicular use still occurs, it is less than in the late 1980s. Today, recreational use is primarily hiking, with an increasing percentage of bicycle traffic along the Arizona Trail.

Overnight camping by migrants from Mexico spiked in the early 2000s. The area is still used for occasional movement of people and drugs, particularly south of I-10.

Fires have been infrequent and small since 1986. During the term of the field study, there was one fire of approximately nine acres. Caused by an illicit recreational campfire, it was the largest fire in the Preserve in decades.

Early motor vehicle traffic from Tucson to Benson in the 1920s passed through the Cienega Gap, and in the early 1950s interstate highway construction began (Behlau 2000). Several pipelines, electric transmission lines, and utility maintenance roads run through or adjacent to the Preserve.

Residential construction is advancing all around the Preserve; some of this development is supported by the same aquifer that supplies the Creek. Development of 15,000 houses at the upper end of the Preserve and concomitant groundwater pumping was avoided through land acquisition by the Regional Flood Control District (Fonseca 2003), but low-density, rural development continues on some private land parcels.

RESULTS: VEGETATION COMMUNITIES

The dominant vegetative community in upland settings is creosote (*Larrea tridentata*) desertscrub (Figure 10a-c). Upland vegetation occurs primarily on Pleistocene alluvial slopes or terraces above the pre-1880 floodplain; soils here are often colored orange with clays and contain abundant cobbles or gravel on the surface.

CIENEGA CREEK NATURAL PRESERVE

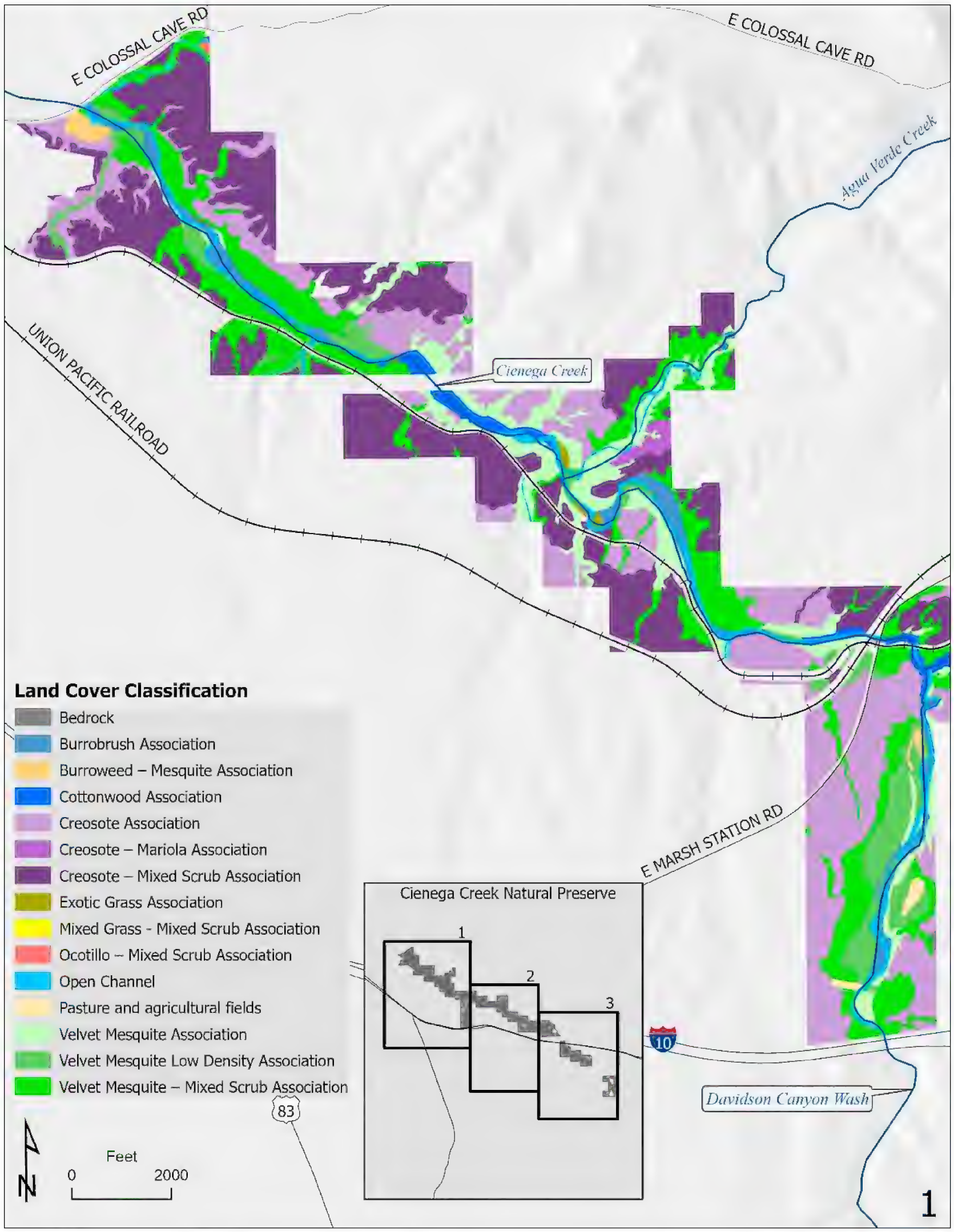

Figure 10a. Vegetation associations of the Cienega Creek Natural Preserve mapped for this study based on 2019 conditions. (Refer to text for explanation, based on the associations of Brown 1994).

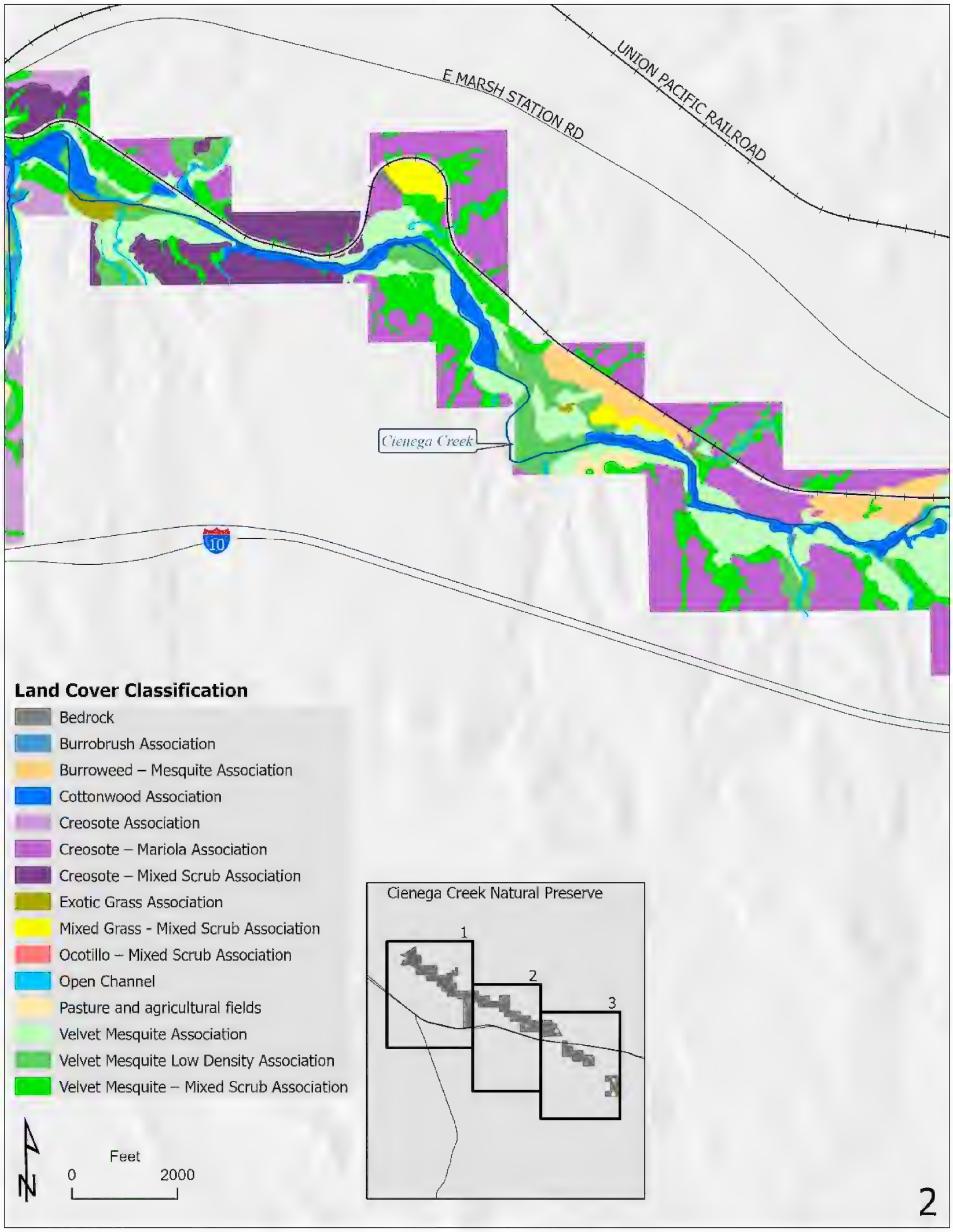

Figure 10b. Vegetation associations of the Cienega Creek Natural Preserve mapped for this study based on 2019 conditions. (Refer to text for explanation, based on the associations of Brown 1994).

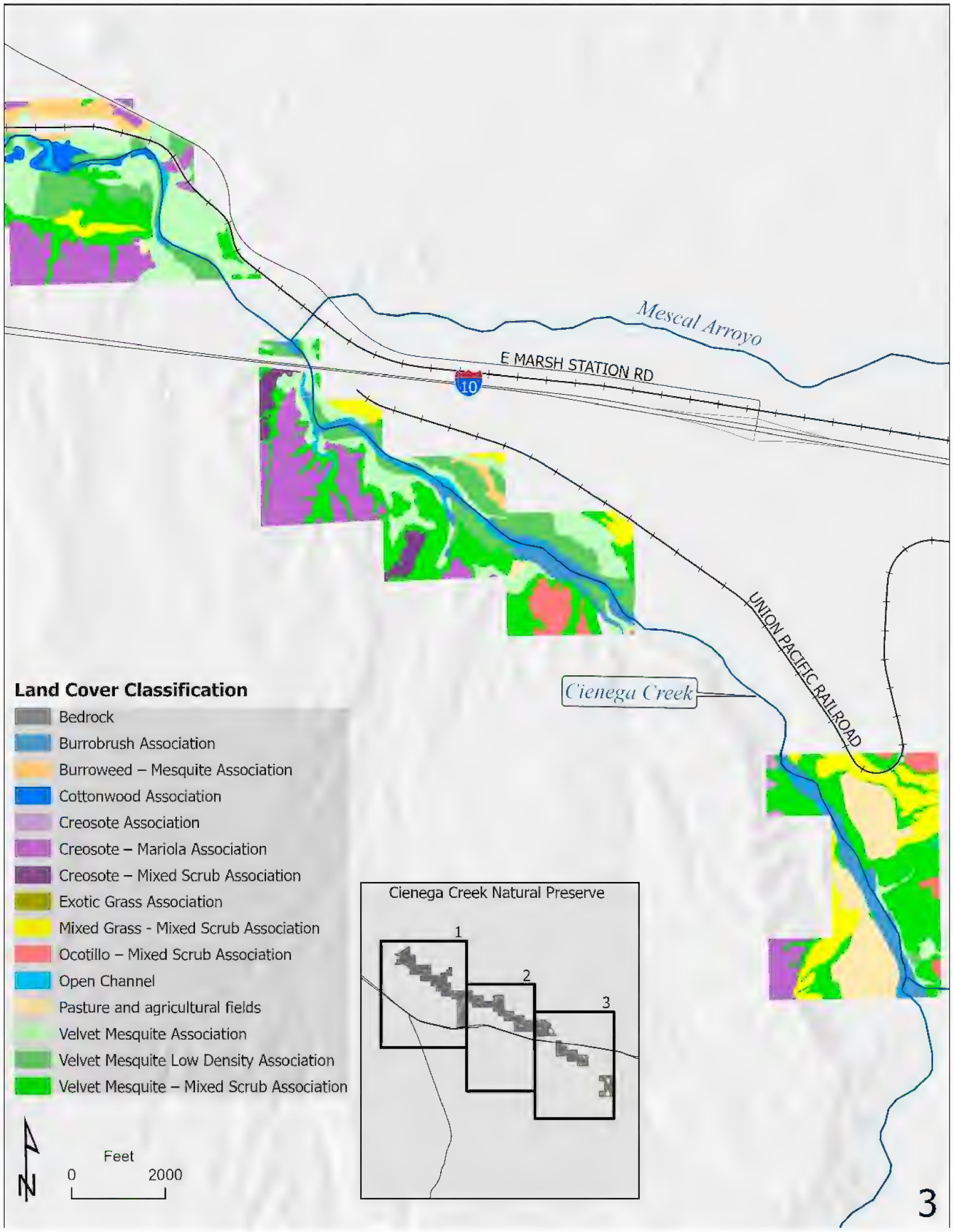

Figure 10c. Vegetation associations of the Cienega Creek Natural Preserve mapped for this study based on 2019 conditions. (Refer to text for explanation, based on the associations of Brown 1994).

The Preserve's geologic substrates and regional position between Sonoran Desert and Chihuahuan Desert ecosystems contributes to vegetation diversity and heterogeneity within the preserve, especially in upland areas. Bedrock outcrops of Cretaceous andesite, consolidated Tertiary sediments, and Pleistocene alluvium are found in uplands. The upland vegetation can be subdivided into Sonoran (154.1) or Chihuahuan desert(153.2) elements using the hierarchical typology of Brown (1994). Chihuahuan upland occurs primarily in the eastern Preserve, with *Fouquieria splendens*, *Yucca elata*, *Agave palmeri*, and *Vachellia constricta* being visually prominent in these units. Sonoran upland vegetation occurs in the western Preserve and on warm slopes with *Carnegiea gigantea* and *Parkinsonia microphylla* being the visually prominent elements (Figure 11).

Along the length of the Preserve, the bottomland vegetation is broadly consistent with elements of Warm Temperate Interior Southwestern Riparian Deciduous Forest and Woodland (223.2) and Sonoran Riparian Deciduous Forest and Woodland (224.5) described by Minckley and Brown (in Brown 1994), with elements of Sonoran Riparian Scrubland (234.7) on some ephemeral channels. Vines are well-represented in the summer aspect of mesquite woodlands forming inside the modern floodplain.

The bottomland vegetation units are found on fine-grained Holocene terraces and sand or gravel floodplains of Cienega Creek and its tributaries (Figure 2). The bottomlands have access to groundwater or enhanced surface water runoff, whereas most upland vegetation does not. South of I-10, *Prosopis velutina* woodlands with *Sporobolus wrightii* and other grasses occur on floodplains and lower terraces. Along the wetter parts of the channel, north of I-10, forests of *Populus fremontii* and other broadleaf deciduous trees are visually prominent.

Although a number of wetland-adapted herbaceous species continue to thrive in and along the remaining wet channel segments, they are located primarily under broadleafed tree canopies. There are no examples of well-developed and persistent, marshy, or cienega, vegetation in open areas outside the channel.

In remapping the area, I separated McGann's Bedrock and Sparsely Vegetated Channel unit into two categories based on the supervised classification, and mapped three new vegetation associations: Burrobrush (*Ambrosia monogyra*), Cottonwood (*Populus fremontii*), and Exotic Perennial Grass (Figure 12, Table 1).The adjusted map units are described further below.

Upland Components

Mixed Grass–Mixed Scrub Association (143.155). This Chihuahuan upland unit is characterized by lack of a dominant plant species. It is primarily found in the eastern Preserve, on south-west facing alluvial slopes and Pleistocene terraces. The principal tree is velvet mesquite (*Prosopis velutina*), with visual prominence lent by *Yucca elata*; occasional *Juniperus arizonica*. *Eragrostis lehmanniana* and *Vachellia constricta* are often present.

BURROWEED–MESQUITE (ISOCOMA-PROSOPIS) ASSOCIATION (143.163). Burroweed (*Isocoma tenuisecta*) is found primarily in areas of mechanical or intense livestock disturbance on Pleistocene alluvial terraces. Although this vegetation type also occurs on some disturbed Holocene terraces, in many places the unit has transitioned since 1993 to other vegetation associations, mainly Velvet Mesquite-Mixed Scrub (234.712). Cholla cactus (*Cylindropuntia* spp.) are often a visually prominent element of this association. *Atriplex canescens* and *Gutierrezia microcephala* may also be present.

CREOSOTE–MARIOLA (LARREA-PARTHENIUM) ASSOCIATION (153.212). This is the most common upland vegetation community. It is found throughout the Preserve on alluvial slopes, bedrock, Pleistocene terraces, and some dry tributaries. This Chihuahuan desertscrub unit is dominated by the presence of *Larrea tridentata* and *Parthenium incanum*, with other shrubs such as *Vachellia constricta*, *Aloysia wrightii*, *Tiquilia canescens*, *Ephedra trifurca*, *Zinnia acerosa*, and *Croton pottsii*. Succulents such as *Yucca elata*, *Dasylirion wheeleri*, and various *Opuntia* and *Cylindropuntia* species are also present.

Figure 11. Cienega Creek near Davidson Canyon confluence. Foreground Sonoran desertscrub on andesite bedrock outcrops, with Fremont cottonwood forest (*Populus fremontii*) in fall colors midground, creosote-dominated desertscrub in background. Photograph copyrighted 2011 by Michael McNulty, used with permission.

Figure 12. Floodplain grassland dominated by *Sorghum halepense*. Brian Powell, Pima County, 2016.

Table 1. Map units for the land cover of the Cienega Creek Natural Preserve

Name of mapping unit	**Brown (1994) Class**
Mixed Grass – Mixed Scrub Association	143.155
Burroweed – Mesquite Association	143.163
Creosote – Mariola Association	153.212
Ocotillo – Mixed Scrub Association	153.261
Creosote Association	154.111
Creosote – Mixed Scrub Association	154.125
Bedrock	None
Exotic Perennial Grass	None
Velvet Mesquite Association	224.521
Velvet Mesquite Low Density Association	224.521
Velvet Mesquite-Mixed Deciduous Tree	224.523
Cottonwood Association	223.211
Velvet Mesquite – Mixed Scrub Association	234.711
Burrobrush Association	234.712
Open channel	None
Disturbed / agricultural fields	None

OCOTILLO (FOUQUIERIA)–MIXED SCRUB ASSOCIATION (153.261). This minor Chihuahuan desertscrub unit is primarily found on high, Pleistocene hilltops and alluvial slopes in the eastern Preserve south of I-10, often on caliche-rich soils. Trees such as *Prosopis velutina* may be present, along with grasses such as *Sporobolus contractus* and shrubs such as *Vachellia constricta*.

CREOSOTE (LARREA) ASSOCIATION (154.111). This Sonoran desertscrub unit is found mainly on sandy terraces and gentle alluvial slopes, as well as in certain dry tributaries in the western Preserve. As the name suggests, *Larrea tridentata* is dominant and trees such as *Prosopis velutina* is only a minor component, if present at all. Grasses include perennials such as *Dasyochloa pulchella* as well as annuals. *Yucca baccata* and *Ambrosia tridentata* are notable but uncommon components. Common succulents include *Ferocactus wislizeni*, *Yucca elata* and various *Opuntia* species.

CREOSOTE (LARREA)–MIXED SCRUB ASSOCIATION (154.125). This is a major Sonoran desertscrub unit, occurring on vegetation-mantled bedrock and coarse-textured alluvial slopes near Davidson Canyon and in the western part of the Preserve. It is far more diverse than the Creosote Association. Visually prominent species include *Carnegiea gigantea*, *Parkinsonia microphylla*, and *Agave palmeri*. *Prosopis velutina*, *Vachellia constricta*, and even *Juniperus arizonica* may also be present.

BEDROCK. This new map unit is restricted to consolidated bedrock outcrops with very limited reflectance from vegetation. Rock types vary, but the spectral signature is distinct from alluvium in channel bottoms. Vegetated bedrock or bedrock overlain with a thin soil cover is mapped according to its vegetation association.

Bottomland Components

VELVET MESQUITE (PROSOPIS VELUTINA) ASSOCIATION (224.521). This vegetation type is dominated by a relatively homogenous closed canopy of mature mesquite along Cienega Creek and its major tributaries. Floodplain occurrences are generally characterized by young, healthy trees. On high Holocene terraces, the canopy has been thinned as these older trees die from lack of water. *Sporobolus wrightii* or *Larrea tridentata* may be present on high terraces, along with succulents such as *Ferocactus wislizeni* and *Cylindropuntia* spp., and shrubs such as *Ziziphus obtusifolia*. On floodplains and low terraces, an understory of native and exotic grasses, including *Bromus*, *Chloris* and *Elymus*, is often present. *Parkinsonia florida*, *Celtis reticulata*, *Senegalia greggi*, *Juglans major*, *Juniperus arizonica*, and *Sambucus nigra* may also be present on floodplains. Vines such as *Clematis drummondii* are an important seasonal component on the floodplain.

VELVET MESQUITE (PROSOPIS VELUTINA)–LOW DENSITY ASSOCIATION (224.521). This unit is similar to the above, but characterized by widely spaced, tree-form mesquites, and thus bears

the same number. The lack of a closed canopy permits a substantial perennial grass or annual understory. In some places, it could be described as a savanna. It is found on floodplains and terraces along Cienega Creek and Davidson Canyon where trees have access to groundwater, including in areas of former disturbance by fire, flood, or mechanized equipment. Grass species may include *Sporobolus wrightii*, *Sorghum halepense*, *Sporobolus cryptandrus*, as well as others.

COTTONWOOD (POPULUS) ASSOCIATION (223.211). This is a Sonoran riparian forest unit found along the wettest portions of Cienega Creek's channel and active floodplain. This unit largely replaced McGann's velvet mesquite (*Prosopis velutina*)-mixed deciduous tree association, but some boundaries were adjusted to reflect the current distribution. *Populus fremontii* now forms the dominant canopy in these areas. Young *Fraxinus velutina* trees can be present, along with old *Salix gooddingii* trees. Small numbers of *Tamarix chinensis*, *Senegalia greggii*, *Juniperus arizonica*, and *Celtis reticulata* may also be present. Shrub components often include *Baccharis salicifolia*. *Sorghum halepense* or various wetland plants may be present in the understory. Conditions are too wet and shaded for cacti or other succulents.

VELVET MESQUITE (PROSOPIS VELUTINA)–MIXED SCRUB ASSOCIATION (234.711). This is a Sonoran riparian scrub community found along the margins of the Cienega Creek valley or in the bottom of the more mesic tributaries. The unit also occurs in the transition from the Holocene terraces to adjacent hillslopes and higher, dried terraces. Mature *Prosopis velutina* and *Cercidium floridum* are generally small and do not form a continuous canopy. Shrubs in tributaries may include *Lycium* spp. and *Anisacanthus thurberi*. This association also occurs on some abandoned agricultural fields and mechanically disturbed Holocene terraces that were formerly mapped as Burroweed-Mesquite (*Isocoma-Prosopis*) Association, where it may retain some *Isocoma tenuisecta*.

EXOTIC PERENNIAL GRASS ASSOCIATION. This new mapping unit is found in sandy or silty parts of the floodplain of Cienega Creek, where flood scour has not recently occurred and canopy cover is largely absent. Streamflow may be ephemeral but a water table is not far below the surface. The exotic is largely monotypic *Sorghum halepense* in these settings. This association was not mapped by McGann and Associates (1994) because it was not present as a mappable unit at that time. An additional, monotypic grassland of *Panicum antidotale* is included in the mapped unit.

BURROBRUSH (AMBROSIA MONOGYRA) ASSOCIATION (234.712). This newly mapped shrubland unit occurs primarily in ephemeral reaches of Cienega Creek and Davidson Canyon on areas that were mapped as sparsely vegetated channel in 1994. Substrates are generally sandy. *Ambrosia monogyra* is dominant. Other shrubs may include *Baccharis sarothroides* or *Baccharis salicifolia.* More rarely, *Chilopsis linearis* subsp. *arcuata* may occur. Forbs such as *Eriogonum* spp., *Mentzelia* spp. and *Polanisia dodecandra* are commonly present. This

association was not mapped by McGann and Associates (1994), having replaced some of their "bedrock/channel bottom" unit.

DISTURBED/AGRICULTURAL FIELDS. Natural and assisted revegetation processes have reclaimed some of the former pastures since 1994, but I mapped other pre- and post-1994 disturbances, mainly associated with road or underground utilities. Abandoned fields occur primarily south of I-10, and one is still used for livestock activities. These areas are characterized by bare fine-textured soil, *Cynodon dactylon*, and/or disturbance-related forbs such as *Salsola* spp. and *Solanum elaeagnifolium*. Scattered *Prosopis velutina* are visually prominent.

OPEN CHANNEL. The extent of this mapping unit has declined over time. The channel unit is sparsely vegetated with forbs, mainly *Eriogonum* spp., *Mentzelia* spp. and *Polanisia dodecandra*. Trees and shrubs are absent or scarce, and sediment, generally gravel, is present. The spectral signature of sediment is distinct from bedrock and other categories; the unit is not mapped where there is a sufficient vegetation to interfere with the mineral reflectance. Flow in the channel may or may not be present.

Changes in Distribution of Vegetation Associations

The principal change in plant association boundaries since the early 1990s is the reduction of the Open Channel unit. Three plant associations, Burrobrush (*Ambrosia monogyra*), Exotic Perennial Grass, and Cottonwood (*Populus*), now take the place of some former Open Channel. In ephemeral reaches, channel extent was reduced by growth of the Burrobrush Association and Exotic Perennial Grass. In perennial flow reaches, the channel narrowed or became obscured completely by the Cottonwood (*Populus*) Association. The latter also completely replaced a *Prosopis-Populus* mapping unit that bordered the open channel.

The profound expansion of *Populus fremontii* forests in the bottomlands during the late 1980s and 1990s is illustrated in Figure 13a-13c. The active channel narrowed by an average of 44% as the forest expanded, based on Pima Association of Governments' analysis (PAG 2002). This trend largely reversed during the new millennium.

A third change in plant communities concerns the trajectory of disturbed areas. In 1994, the principal mapped disturbances were those associated with mechanical clearing of *Prosopis*-dominated forests and woodland for livestock pastures in the 1960s and 1970s. These areas were mapped as either agricultural or Burroweed-Mesquite (*Isocoma-Prosopis*) Association. Since then, some of the Burroweed-Mesquite Association has transitioned to other vegetation associations, mainly Velvet Mesquite (*Prosopis velutina*)-Mixed Scrub. In most cases this occurred naturally, but in one area, the process was assisted with plantings of container stock grown from seeds collected in the Preserve.

Some clearings have not changed over time, either due to continued livestock use (south of I-10) or due to soil alteration from the original pasture clearings of the 1960s and 1970s. Field observation indicates that fire was used to burn piles of *Prosopis velutina* on terraces.

There have been new clearings, mainly for trailhead or other recreational access. Excluded from the mapping is the removal of mature *Prosopis velutina* and *Populus fremontii* forest under a transmission line right-of-way in 2009. *Populus fremontii* quickly regrew, but *P. velutina* has not.

No plant association boundaries were changed due to fire-related disturbances since the original mapping. Increased sinuosity of the channel has slightly altered boundaries between vegetation units located in the floodplain versus the adjacent terraces.

Shrub encroachment

The Preserve is an excellent example of the loss of grasslands to shrub encroachment. Photographs and historical accounts (such as those in Figure 10a and 10b, see also Turner et al. 2003) indicate that much of the upland and bottomland vegetation consisted of grasslands prior to channel down-cutting and overgrazing by livestock in the late 1800s. Grasslands were replaced with mesquite forests and woodlands in the bottomlands, and the uplands are now dominated by creosote and other desert shrubs. Thus, aside from a few remnants, most of the woody plants we see today are probably less than 140 years old.

Figure 13a. Cienega Creek in 1988, shortly after livestock grazing at this location ceased. Mature trees here are primarily Goodding willow (*Salix gooddingii*), with deergrass (*Muhlenbergia rigens*), bulrush (*Schoenoplectus americanus*), rabbitfoot grass (*Polypogon monspeliensis*) and cottonwood (*Populus fremontii*) saplings along the channel. Photograph by Julia Fonseca, Pima County.

Today I see little evidence for continued shrub encroachment. Large, non-native perennial grasses have increased in the floodplain, to the extent that a new grassland map unit can be added. In the uplands, perennial and annual grasses tend to colonize areas of disturbance within the desertscrub, though these do not rise to dominance.

This is not to say that shrubs are no longer recruiting. I observed *Larrea tridentata* and *Parkinsonia microphylla* seedlings during the intensive field surveys. *Larrea tridentata* appear to be replacing *Prosopis velutina* on certain high, desiccated terraces.

Changes in Recruitment of Riparian Trees

In the early 1980s, there were few mature *Populus fremontii,* and only narrow bands of mature *Salix gooddingii* bordering the channel (Figure 13a). *Populus fremontii* germinated following the October 1983 flood, according to local residents who lived along the stream. I observed reductions in the herbivory of the young tree seedlings and saplings when we reduced the intensity and distribution of livestock, starting in 1987.

Figure 13b. Maturing cottonwoods (*Populous fremontii*) obscure the view at same location, 1998. Seepwillow *(Baccharis salicifolia*) in the foreground, deergrass (*Muhlenbergia rigens*) and bulrush (*Schoenoplectus americanus*) in background. Photograph by David Scalero, Pima County.

Figure 13c. Mature cottonwood (*Populus fremontii*) forest, same location, in September 2020. Note lack of streamflow. Photograph by Ian Murray, Pima County.

Some otherwise dominant species showed no evidence of recruitment during the intensive field studies 2013–2019. I documented a pulse of *Populus fremontii* and *Tamarix chinensis* seedlings in 2018, but few of these appear to have survived. No evidence of successful new *Salix gooddingii* recruitment was seen. *Fraxinus velutina* is the primary broadleaf riparian tree colonizing the intermittent and perennial portions of the channel, with minor additions of *Juglans major*.

Areas where the forest of *Prosopis velutina* is either dying back or not being replaced occur primarily on Holocene terraces that are stranded high above the floodplain. At the same time, healthy mesquite continue growing on lower Holocene terraces, particularly where tributary streams remained unentrenched, or presumably, where the groundwater table has remained within the root zone. New *P. velutina*, *Senegalia greggii*, and *Celtis reticulata* trees continue to establish on the active floodplain of Cienega Creek and on certain formerly cleared Holocene terraces along Davidson Canyon.

Recruitment is a long-term concern because prolonged drought has diminished the extent of *Populus fremontii* that established during the previous "pluvial" period (Figure 6, 7). Interpretations of data collected in 2005 and 2011 (Swetnam et al. 2013) showed loss of canopy coverage in the drier channel reaches and on the high terraces. This is expected as a response to drought and lowering of the water table. The extraordinary lack of summer rainfall in 2020 killed more drought-stressed *P. fremontii* along the ephemeral reaches of the Preserve.

Increased base flows and higher groundwater levels have followed the July 2021 flood (Figure 8), which was the largest flow since 1958 (USGS 2022). The freshly deposited, wet mineral substrates offer potential new sites for recruitment; *Populus fremontii* seedlings can now be seen in the newly opened sites along Cienega Creek and Davidson Canyon. U.S. Bureau of Reclamation models of surface water runoff for continuing rates of greenhouse gas emissions would predict less reliable baseflows and winter runoff, and more variable levels of summer runoff for the Cienega watershed (USBR 2021). It is beyond the scope of this study to determine whether the abundance of water in 2022 can be sustained long enough to replace lost canopy.

RESULTS: FLORA

Summary

The Cienega Creek Natural Preserve is rich in plant diversity. The cumulative number of species and infraspecific taxa found in the Preserve during the period 1986 through 2021 is 551, and these are listed in the SEINet checklist, even if the taxon was present only briefly. There are 336 genera and 88 families with Asteraceae and Poaceae the largest families represented in the flora. There are 61 non-native taxa, including several previously unrecorded species.

A total of 507 species and infraspecific taxa were documented within the Preserve during the field surveys, 2013–2021. This number is used for comparison to other regional floras (Table 2). An annotated checklist (Appendix A, Plant Profiles) reflects species observed and confirmed with some kind of record, physical or photographic, between 1986–2021, inclusive of observations by others during that time period.

A species accumulation curve for specimens I collected since 2013 does not approach an asymptote (Figure 14). In fact, the relationship is nearly linear ($r^2=0.99$), and it is extremely unlikely to be the result of chance ($P<0.001$). Thus the flora can be regarded as incomplete, and at the current rate, no foreseeable level of effort would make it so.

Spatial Trends and Patterns

There is a pronounced change in the flora from west to east, shifting from Sonoran desertscrub to Chihuahuan semi-desert scrub. For instance, *Encelia farinosa*, *Jatropha cardiophylla*, *Parkinsonia microphylla*, *Ambrosia tridentata*, and *Carnegiea gigantea* are confined to the western half of the Preserve. *Lycium pallidum* is found only in the eastern half of the Preserve, and *Rhus microphylla* becomes more common there. *Sporobolus wrightii* is mainly found south of I-10 in the eastern Preserve. The development of the *Ambrosia monogyra* plant community in the bottomlands represents an extension of an essentially Sonoran desert plant community into what has historically been Chihuahuan grassland.

The tributaries often have a different set of plants, generally more xeric than the main channel. Large tributaries contribute species that are either rare or absent elsewhere. For instance, Davidson Canyon drains the northern Santa Rita and Empire mountains, and seems to bring with it several species that are not found or are rare elsewhere in the Preserve including *Tetramerium nervosum* and *Schistophragma intermedia.* Anderson Wash originates in the Whetstone Mountains; it has species such as *Baccharis brachyphylla* and *Talinum*

paniculatum. The Agua Verde confluence is exceptionally rich with species affiliated with the Rincon Mountain flora such as *Passiflora mexicana, Erythrina flabelliformis* and *Oenothera elata.*

The dark-brown andesite porphyry bedrock substrate offers one of the most interesting settings in the Preserve (Figure 11). The andesite tends to erode into landforms that offer deep pockets for alluvial soil, irrigated by runoff from bare bedrock outcrops, and shaded by cliffs. This diverse microtopography offers sites for a number of species not found on other sites including *Quercus pungens, Notholaena standleyi, Myriopteris lindheimeri, Justicia longii,* and *Allium macropetalum.* These rock outcrops also provide seasonal wildlife waters.

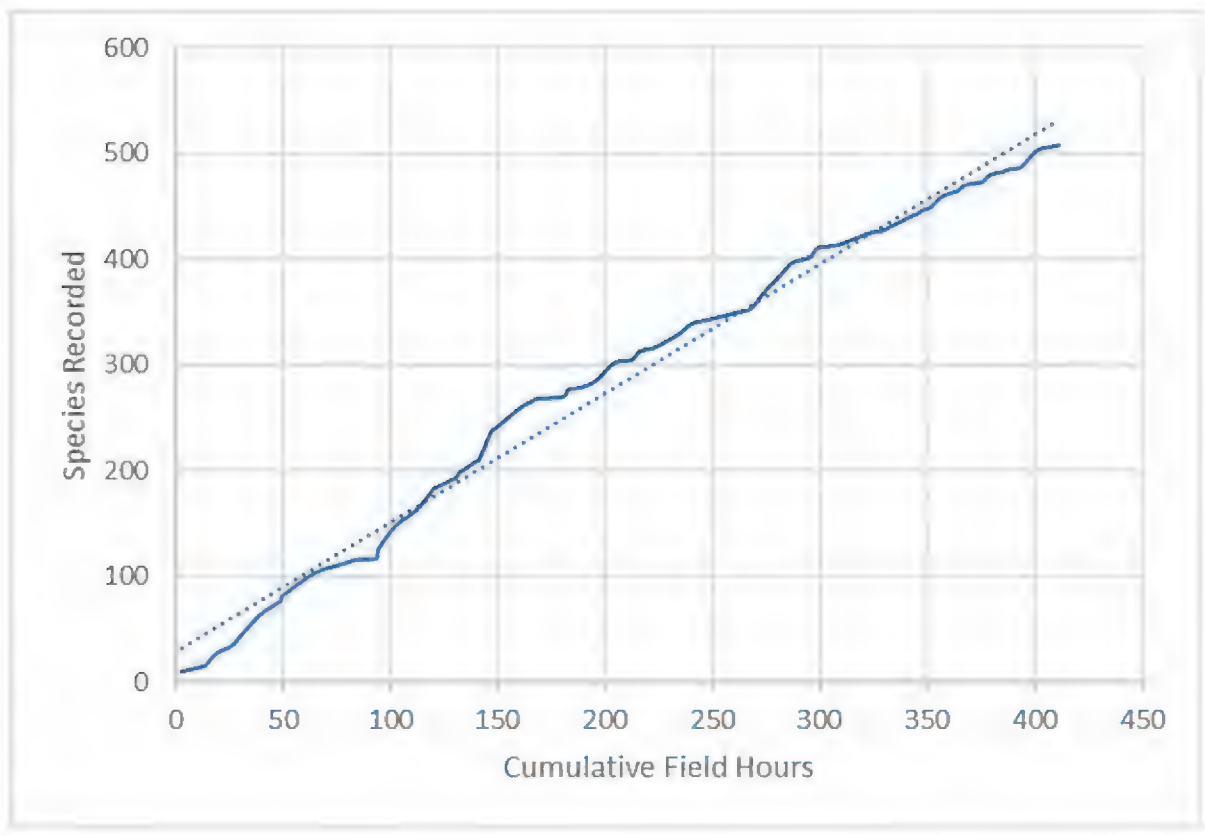

Figure 14. Species accumulation curve for specimens (including photographic vouchers) collected 2013-2021.

Table 2. Comparison of regional floras for riparian valleys with their adjacent uplands.

Flora Name (Citation)	**Total Taxa**	**Area (ha)**	**Elevation range (m); min. elev. (m)**	**Effort**
San Pedro (Makings 2006)	625	19,291	302; 1203	115 trips; 3 years
Sonoita Creek (McLaughlin 2006)	561	1990	230; 1008	34 trips; 1.4 years
Tumacacori (Powell et al. 2005)	378	128	105; 987	19 trips; 3 years
Cienega Creek (this work)	508	1726	260; 953	78 trips; 7 years
Las Cienegas (Solves 2017)	406	18,210	248; 1203	31 trips; 3 years

Several taxa in the Preserve flora prefer the dry, exposed, mudstone of Pantano Formation: *Oenothera suffrutescens, Verbesina rothrockii,* and *Thelesperma megapotamicum*. *Eriogonum terrenatum*, a rare, perennial buckwheat confined to Pantano Formation claystone units, was not found in the Preserve, despite intensive searches, but at least one population just outside the Preserve is still in good condition.

Limy substrates also influence plant communities. Soils with substantial calcium carbonate accumulations are widely distributed in the Preserve on Pleistocene alluvial slopes, and favor species like *Fouquieria splendens, Dasylirion wheeleri,* and *Heteropogon contortus.* Though minor in extent, bedrock outcrops of limestone do exist, and have their own suite of associated species such as *Astrolepis sinuata*.

Non-native Species

Exotic species have a long history in the Cienega watershed. One early account of measures to halt erosion states that:

> *Mr. Harry L. Heffner.....has experienced a great deal in this matter. The plan which he has adopted has been [to?] establish plantations of Sorghum halepense upon the lands near the ends of the deep, narrow gorges and washes which approach the Pantano Wash...Bermuda grass has also been tried* (Griffiths 1904).

Today, *Sorghum halepense* forms dense stands in some wide, open floodplains, and is common elsewhere in the floodplain of the Preserve (Figure 12). *Panicum antidotale* sometimes occurs with *Sorghum halepense*.

Previous survey efforts (PAG 2003) identified the abundance of sixteen non-native plant species within the Preserve boundaries, mostly grasses. This affords an opportunity to compare the observed distributions between PAG's 2003 survey and my own observations based on intensive field work 2013–2019 (Table 3). PAG conducted seven field trips during the fall seasons of 2001–2003, mainly along the main channel, the railroad rights-of-way, and to locations of non-native plants I specified. Table 3 includes only species noted by PAG.

Many of the exotic species I found were not discussed or mapped by PAG in 2003; PAG's objective was to identify distribution of non-native species of most management concern. We should not assume that lack of an antecedent detection by PAG is evidence of an increase. Indeed there are a number of non-native species which were not mentioned in the PAG inventory that were observed previously or contemporaneously by others. For instance, Theresa Wright (1823 NHI) observed *Brassica tournefortii* as early as 1996; Kathryn Mauz had collected *Echinochloa crus-galli* (100 ARIZ) in 2004. However, for the species included in PAG's survey, we can note some changes.

In 2003, PAG documented only three separate populations of *Cenchrus ciliaris* all of which were on mechanically disturbed areas. Since then, *Cenchrus ciliaris* has increased its prevalence and has moved into a variety of natural settings. I see it particularly along hot, sunny, tributary channel banks and alluvial slopes, primarily in the lower elevations of the western Preserve.

The species with the greatest abundance in 2003 and today is *Eragrostis lehmanniana.* It occurs in both bottomland and upland settings and seems to favor areas that were mechanically disturbed.

Arundo donax locations in the Preserve increased. These are the uppermost known locations for this watershed. Since the end of my field survey, Pima County Regional Flood Control District staff has successfully removed a number of the clumps. Despite attempts to work with owners, domestic locations on tributaries outside the Preserve remain as source populations. Still, the influx rate appears to be low, and periodic removals could conceivably control its spread within the Preserve.

Table 3. Comparison of non-native species abundance to Pima Association of Governments (2003) inventory. Non-native species listed here are confined to those mapped in PAG (2003).

Taxon	**Abundance (this study)**	**PAG (2003) abundance**
Argemone ochroleuca	Infrequent	Not reported
Arundo donax	Infrequent, multiple clumps	One clump
Bromus rubens	Infrequent	Scattered after wet winters
Cenchrus ciliaris	Occasional	Three populations
Cynodon dactylon	Occasional	Very common
Echinochloa colona	Occasional	One population
Eragrostis cilianensis	Infrequent	One population
Eragrostis lehmanniana	Abundant	Ubiquitous on uplands
Eragrostis superba	Rare	One population
Melinis repens	Not found	One population
Nasturtium officinale	Occasional	Common
Panicum antidotale	Infrequent	One population
Salsola kali	Common	Common in disturbed areas
Sisymbrium irio	Common	Throughout CCNP
Sorghum halepense	Abundant	Very common
Tamarix chinensis	Occasional	Small, scattered stands
Vinca major	Rare, no change	One clump

The distribution of *Panicum antidotale* has expanded. The abundance of *Cynodon dactylon* may have been reduced, perhaps as a result of drought.

In the 1980s, *Bromus rubens* was a dominant ground cover under *Prosopis velutina* woodlands and forests. A long succession of wet winters in combination with grazing contributed to dense stands. There was concern this would promote fire, particularly after the removal of livestock. While a few small fires did occur along the railroad, no major fire damage occurred after removal of livestock. By 2003, PAG found only "scattered" growths. Today *Bromus rubens* is no longer a principal cover type even after heavy winter rains, whereas *Sisymbrium irio* remains abundant under such conditions.

In the 1980s, blankets of *Tamarix chinensis* seedlings were present each summer and a number of clumps were already maturing along the main channel. Management efforts in the 1990s focused primarily on removal of *Tamarix*. Stem cutting with application of Garlon herbicide did not significantly reduce the extent of *Tamarix* but drought trends and the removal of livestock seemed to help abate new establishment, perhaps through competition. I did not see any new *Tamarix* seedlings germinate in the streambed from 2013 to 2017. *Tamarix* recruitment was evident in 2018, perhaps as a result of the July 2017 flood, but these seedlings were no longer evident by 2019.

There are two species of concern in the Agua Verde floodplain just outside Preserve boundaries: *Melinis repens* and *Cenchrus setaceus*. *Melinis repens* was reported by (PAG 2003) and I removed the single specimen of *Cenchrus setaceus* I observed the Preserve boundaries during intensive field surveys. These two species, rare today, may expand greatly in the future, especially given the removal of so much vegetative cover downstream of Agua Verde by the July 2021 flood.

Protected Species

Pima Pineapple Cactus**.** According to Marc Baker (2005) *Coryphantha scheeri var. robustispina* usually occurs on distal bajadas with gravelly topsoil between 800 and 1185 m, where *Cylindropuntia fulgida*, *Larrea tridentata*, and/or *Prosopis velutina* are dominant or co-dominant woody perennials (Baker 2005). Baker observed three cacti in one area of the western Preserve in 2000, but neither I nor other County staff have encountered the species in the Preserve boundaries. If present, the cactus would be at the northeastern margin of its distribution.

Huachuca Water Umbel. Priscilla and John Titus (Titus 2001) found one small patch of *Lilaeopsis schaffneriana* ssp. *recurva* in one of eight stream segments surveyed in the Preserve in 2001. The plants were missing at the same location during a 2002 resurvey. The patch was only 10 cm by 31 cm (4 in by 12 in) in size, totaling 30 leaves connected by a rhizome amongst *Typha domingensis* in sandy, saturated soil. No surface water was present in the location of the plants when surveyed. Suitable sites exist within the Preserve in silty, clayey microsites at the edge of the main channel (Titus 2001). Pima County intends to re-introduce this species to Cienega Creek (Powell & Fonseca 2019).

Arizona Giant Sedge. *Carex ultra* (*Carex spissa* var. *ultra*) is an Arizona rare plant that occurs in multiple, generally shaded locations in the Preserve, particularly where there is seeping discharge of groundwater through the channel bank. During the course of this study, I observed that the individual clumps of this species recovered after a small fire in 2017.

Comparison to Regional Riparian Floras

Solves (2020) compared the floras of the San Pedro, Cienega Creek Natural Preserve, and Sonoita Creek to the 406 taxa recorded for Las Cienegas National Conservation Area. The percent overlap with Las Cienegas was 47.2% for the San Pedro flora, 43.7% for the 2020 checklist of the Preserve's flora, and 35.6% for Sonoita Creek taxa. All of these compared areas lie further south than the Preserve, a factor which might increase the proportion of their tropical floristic elements due to the higher proportion of monsoon rainfall.

Bowers and McLaughlin (1982) previously noted that area, elevation range and sampling efforts is related to floristic richness as measured in regional (mainly mountain-based) floras. Riparian floras generally have lower elevational ranges than mountain-based floras, so it seems appropriate to compare the Preserve's flora to several others that are primarily located along valley bottoms, including the San Pedro River, the upper reaches of Cienega Creek, Sonoita Creek, and the Santa Cruz River (Table 2). Elevation range of the San Pedro, Las Cienegas and Sonoita Creek floras is similar.

The floristic richness of the 1767-ha (4267ac) Cienega Creek Natural Preserve compares favorably to the San Pedro Riparian National Conservation Area (635 species for a much larger area and longer reach of wet channel; Makings 2006) or the 561 species found in the Sonoita Creek State Natural Area (1990 hectares; McLaughlin 2006). The Preserve's richness is higher than the 18,210-hectare Las Cienegas National Conservation Area located in the higher elevations of Cienega Creek (Solves 2020).

The San Pedro, Las Cienegas and Sonoita Creek floras had much shorter collection intervals and included greater areas compared to this work, so these floras may be undercollected. The 128-hectare Tumacacori National Historical Park, which includes portions of the Santa Cruz River bottomland, had 378 species recorded over three years and species accumulation curves showed little sign of reaching an asymptote (Powell et al. 2005).

Species No Longer Present

One of the motivations for this effort was to understand changes for taxa documented prior to the intensive field surveys. The field surveys added new species to the floral checklist. Many of the species documented prior to this survey period were confirmed to remain in the Preserve's flora, but some of these were not found (Figure 15). On the plant profiles in Appendix A and in Table 4, plants collected or photographed previously but not observed between 2013 and 2021 are marked "not found". Diverse reasons might explain why some species from earlier years are absent. These might include the last two decades of drought, impacts of erosion and sedimentation related to rare but large flood events, or sampling effects. Some small herbs and rare plants were probably overlooked in the collection process. Other

possible explanations for plants that were not found again might include the potential that I conflated the appearance of one species similar in appearance for another, particularly for grasses and other obscure herbs with small flowers. In at least one instance, there was deliberate removal of a non-native plant.

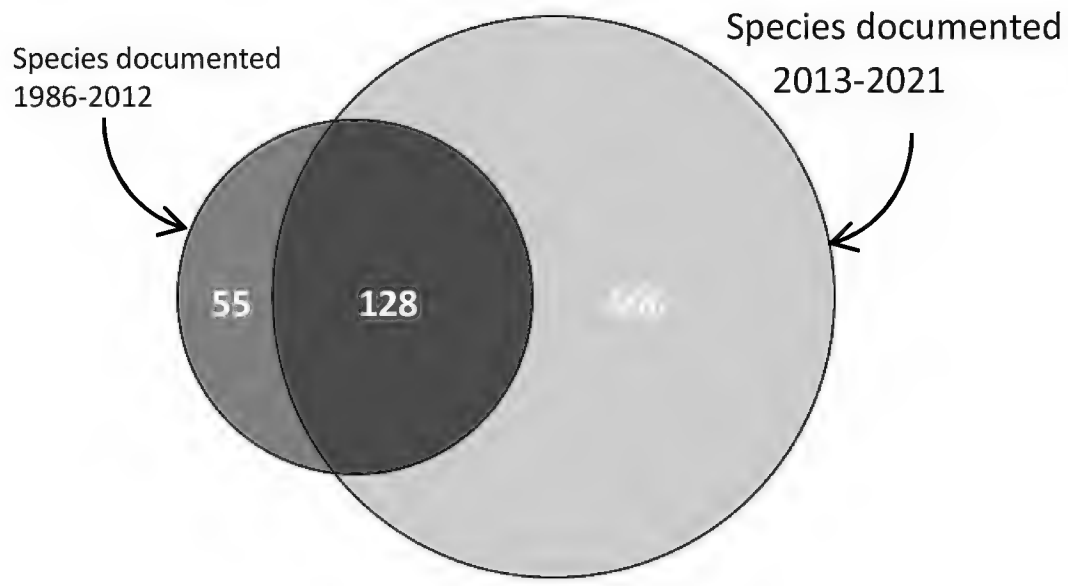

Figure 15. Summary graphic comparing overlap between species known prior to 2013 and species encountered 2013-2021.

Table 4. Taxa previously documented with photographs or specimens since 1986 but not found during the between 2013 and 2021.

Taxon	**Photographic observation† or Voucher(s)**	**Wetland Indicator Status**
Acmispon strigosus	†Cowles 2004-04-02	NA
Androsace occidentalis	Rainey 71 ASU, †Cowles 2004-04-03	FACU
Aquilegia chrysantha	†Fonseca 1993-05-08	FAC
Aristida purpurea var. *parishii*	*White & Shorrock 2006-09-03; Hazelton 108 ASU	NA
Bidens aurea	Mauz 2004-93, †Cowles 2004-09-03	OBL
Bidens heterosperma	†Cowles 2004-08-27	NA
Bidens laevis	Fishbein 549	OBL
Boerhavia megaptera	†Cowles 2004-08-27	NA
Boerhavia pterocarpa	†Cowles 2004-09-04	NA

Taxon	Photographic observation† or Voucher(s)	Wetland Indicator Status
Calandrinia ciliata	†Cowles 2007-03-26	NA
Castilleja minor	†Cowles 2007-04-29	OBL
Centaurea melitensis	†Cowles 2005-08-05	NA
Cortaderia sp.	†Fonseca 1995-09-24	FACU
Crassula connata	†Cowles 2005-04-02	FAC
Croton texensis	†Cowles 2004-04-18	NA
Cryptantha muricata	Wright 1996-04-28	NA
Cyperus squarrosus	†Cowles 2004-09-16	OBL
Dieteria bigelovii	†Cowles 2004-10-21	FACW
Echinochloa muricata	Mauz 2004-100	FACW
Eragrostis lutescens	Shorrock 2005-09-03 ASU	FACU
Eragrostis pilosa	*Hazelton 141 and 126 ASU	FACU
Eriochloa acuminata	*Hazelton 111 ASU	FACW
Eriogonum polycladon	†Cowles 2004-10-24	NA
Erythrina flabelliformis	†Cowles 2006-09-08	NA
Eulobus californicus	†Cowles 2005-03-24	NA
Euphorbia dentata	Shorrock 2005 -09-03 ASU	NA
Gomphrena sonorae	†Cowles 2008-09-22	NA
Haplophyton cimicidum var. *crooksii*	†Cowles 2004-09-26	NA
Heterotheca subaxillaris	Rainey 162 ASU; Fonseca 1993-05-08	NA
Juncus balticus var. *mexicanus*	Tlucek 2009-05-26 ASU; White 2005-06-16 ASU	FACW
Juncus dudleyi	Wright 1824 ASU	FAC
Lactuca serriola var. *integrifolia*	Mauz 2004-113	FACU
Lamium amplexicaule	†Cowles 2005-02-08	NA

Taxon	**Photographic observation† or Voucher(s)**	**Wetland Indicator Status**
Lasthenia californica	*Donna Shorrock 2006-03-08 ASU	FACU
Leymus triticoides	White 2005-06-15 ASU	FAC
Lilaeopsis schaffneriana subsp. *recurva*	†Titus 2001-05-01	OBL
Linanthus bigelovii	†Cowles 2005-03-10	NA
Lupinus brevicaulis	†Cowles 2005-04-23	NA
Mammillaria heyderi	Baker 17248 ASU	NA
Melilotus indicus	†Cowles 2007-04-22	FACU
Nuttallanthus texanus	†Cowles 2007-03-18	NA
Physalis pubescens	†Cowles 2005-09-05	FACU
Portulaca halimoides	†Cowles 2005-09-12	FAC
Portulaca umbraticola	Shorrock 2005-09-03 ASU	FACU
Prenanthella exigua	Theresa Wright 1814-1	NA
Ruta graveolens	Tedford & Yetman 1994-05-26	NA
Salix bonplandiana	Mauz 2004-92	FACW
Salix taxifolia	Rainey 102 ASU	NA
Schismus barbatus	Hazelton 171 ASU	NA
Sida neomexicana	Shorrock 2005-09-03 ASU	NA
Sisyrinchium cernuum	†Cowles 2007-03-26	FAC
Solanum rostratum	†Cowles 2005-09-05	NA
Sphenopholis obtusata	Wright 1823	FAC
Triodanis holzingeri	†Cowles 2007-04-21	NA
Verbena gracilis	*Hazelton 123 ASU	NA

Asterisked records (*) were also found in the seedbank trials for Cienega Creek soil samples reported by Stromberg et al. (2009). Wetland class based on U.S. Army Corps 2020. Obligate species (OBL) almost always occur in wetlands; facultative wetland species (FACW) usually occur in wetlands, but may occur in non-wetlands, facultative (FAC) occur in both wetlands and nonwetlands; facultative upland species (FACU) usually occur in non-wetlands; and upland species (UPL) almost always occur in non-wetlands. NA= not applicable, this is an upland species.

In total, there were 55 out of 551 taxa (or 549 species) observed between 1986 and 2012 that were not confirmed to be present between 2013 and 2021 (Table 3, Figure 15). Many of these taxa were originally observed in the floodplain, where previous collectors tended to roam. Of these, 10 are considered either obligate or facultative wetland species.

Among the wetland species not relocated was *Bidens laevis*, collected by Mark Fishbein in September 1991; it was described as occasional along the flowing stream during that month, but was absent in the preceding and following years. *Aquilegia chrysantha* was observed on May 8, 1993, but I never saw it again. In the 1980s, *Salix bonplandiana* was present near the Marsh Station Bridge, the only one of its kind within the Preserve; this tree (a male) was alive in 2004, but is no longer present. One *Salix taxifolia* in the vicinity of the I-10 bridge in 2001 is also no longer present; it was the only location I ever knew. Huachuca water umbel was detected in 2001 but the plants were thought to have been swept away the following year by a flood (Titus 2001). I and others have searched for this species; it has not recolonized as far as we know. While these native, wetland species are no longer extant, none provided much cover or occurred in great number, except for *Bidens laevis* in 1991.

A high rate of turnover could be expected in flood-prone settings such as these. *Berula erecta* and *Typha latifolia* showed up in 2020 following a large flow event. *Zannichellia palustris*, *Persicaria punctata*, and *Lythrum californicum* seemed to come and go during the term of this study. In any given year, these species might not be encountered in the Preserve.

Table 2 does not include additional species observed by in the field by Stromberg et al. (2009) for which no voucher specimens or photographs exist, such as *Plagiobothrys* sp., *Keckiella antirrhinoides, Hydrocotyle ranunculoides,* and *Amaranthus albus*. *Plagiobothrys* sp. and *Amaranthus albus* were found in the seedbank (Stromberg et al. 2009), but there is no documentation for their occurrence anywhere in the Cienega watershed. *Keckiella* is a conspicuous shrub when flowering and it was observed in the seedbank; although observed by Andrea Hazelton in the Preserve in 2006, her packet voucher was not found in the ASU herbarium, and the nearest population is in Eloy. I observed *Hydrocotyle* once in May 1993, but did not collect a specimen; this species occurs in aquatic sites in Las Cienegas National Conservation Area, but I never observed it again in the Preserve. *Leymus triticoides* is a distinctive wetland plant when mature but is uncommon in Pima County; the nearest modern collection record was in Rincon Creek (Beckman 62 ARIZ).

CHANGES, TRENDS, AND THE FUTURE

Recent Floristic Change

Some species not found during the seven years of intensive collection (*Heterotheca subaxillaris*, *Lactuca serriola*, *Centaurea melitensis*, *Melilotus indicus*, *Lamium amplexicaule*, and *Solanum rostratum* favor disturbed areas. These species may have become much less frequent due to removal of livestock, a reduction in off-road vehicular traffic, growth of a dense tree canopy and small flood peaks in the two decades prior to 2013.

Erosion or desiccation may have since altered habitat conditions, particularly for the Agua Verde Creek confluence observations by photographer Jillian Cowles listed in Table 2. In the early part of the new millennium, the water table under this reach was more accessible, as evidenced by seasonal base flows that began downstream of the confluence and by the presence of cottonwood trees. Progressive desiccation since 2009 has lowered the water table enough to kill mature cottonwood trees in the area (Figure 16).

Figure 16. Dead cottonwood (*Populus fremontii*), floodplain grassland, and riparian woodlands near the Agua Verde confluence. Photograph by Brian Powell, Pima County, 2012.

The species accumulation curve (Figure 14) supports another interpretation: that this is an open system with high rates of replacement. If so, is this the natural condition, or is the area in an ecological transition? If these systems are naturally subject to high rates of turnover in species, then it complicates any effort to interpret missing species as evidence of drought or systemic change. Species accumulation curves by hours of effort are rare in the floristic literature, but I note that when species accumulation was graphed for the Chiricahua National Monument relative to survey effort by Powell et al. (2008), the rate of new species found in the Monument did not decline.

Powell et al. (2005) did not find 46 species that were encountered by previous researchers in the Tumacacori unit, which is a tenth the size of the Preserve but similarly situated along a major watercourse. Due to a failure to detect conspicuous species such as *Parkinsonia microphylla* and *Sporobolus wrightii*, they surmised that local extirpation of these

long-lived perennials had probably occurred. I see no evidence in Table 3 for extirpation of long-lived, common, native perennials in the Preserve.

Stromberg et al. (2009) constructed a series of species accumulation curves relative to area of 10×10 m^2 plots sampled in the Cienega Creek floodplain. All vascular plants were identified. Their curve for dry conditions in April 2005 suggested an asymptote might be reached, but their June and September 2005 curves remained ascending for perennial as well as ephemeral stream segments. The floodplain flora is diverse and appeared to be sampled insufficiently for floristic purposes even with two years of effort and 120 plots. Plot-based species accumulation curves for the San Pedro River and Hassayampa also ascended linearly, and rates of accumulation for intermittent reaches were particularly high (Katz et al. 2011).

In the Preserve, the intermittent, ephemeral and perennial reaches each contribute to species richness; 59% of species occurred in only one hydrologic site type. In addition, the variability of precipitation year to year contributes to richness in the flora (Stromberg et al. 2009), particularly for non-wetland species along Cienega Creek (Katz et al. 2011).

Management and Monitoring

Cienega Creek's floodplain today offers more diverse microsites and greater woody and leafy debris than it did before the County's acquisition. Early County management efforts focused on removing stressors such as livestock grazing and off-road vehicles from the areas north of I-10, and these were transformative. Aided by a favorable climate, the removal of stressors in the 1980s allowed for natural revegetation of many acres of disturbed uplands and increased vegetative resistance to flow in the channel and floodplain, resulting in greater topographic heterogeneity, greater plant diversity, and eventual colonization of the improved aquatic habitat by the Gila topminnow (*Poeciliopsis occidentalis occidentalis*) and Gila chub (*Gila intermedia*).

Land acquisition and removal of the industrial and residential conditional zoning that used to exist in the area have significantly reduced the prospect for development of new satellite cities adjoining the Preserve (Fonseca 2003). These actions marked the beginning of Pima County's effort to create a *de facto* urban boundary for Tucson, consisting of large open-space tracts. This effort continues today through land acquisitions and the Pima County Board of Supervisor's use of Maeveen Marie Behan Conservation Lands System guidelines. These actions, along with elimination of agricultural irrigation on pastures south of I-10, stabilized the natural water supply for much of the Preserve.

Pima County Regional Flood Control District actively worked to establish trees, shrubs and native grasses in a former horse pasture at the Pantano Jungle site in the 1990s, speeding and diversifying the natural revegetation processes that were beginning there (Scalero 2009). The District also obtained instream flow water rights and worked with the state to create more stringent water quality regulations for discharges to Cienega Creek and Davidson Canyon. More recently, work has begun to address some of the most pressing upland erosion issues. The District has continued to discourage off-road vehicular incursions and livestock grazing

through control of access, fencing and signage. Livestock numbers on the County's adjacent ranch have been reduced.

Pima County (2022b) has recently revamped its management plan for the Preserve. The new management plan recognizes climate change as the most serious threat to the Preserve's natural resources, and includes a number of measures to minimize adverse effects from fire. In the future, fire is expected to exert a greater influence on the vegetation communities as human activities increase in the area. Greater pre-fire communication with fire management agencies will help ensure that access and resource protection needs are understood and communication is maintained during fire response.

The management plan includes efforts to expand the stewardship activities by volunteers and acquire additional lands around the Preserve, particularly where such acquisitions could protect groundwater or surface water inputs.

Pima County has recently established monitoring plots to detect changes in the composition of perennial vegetation and soils here and elsewhere in eastern Pima County at various elevations. These plots will permit conclusions to be reached about the long-term direction of upland floristic change and soil conditions in a more robust way than this flora can provide. Trends in bottomland vegetation will be based on imagery analysis, coupled with field observations by staff.

Future Prospects

The U.S. Bureau of Reclamation has modeled reductions in monsoonal and winter rainfall for the Tucson Basin and continued increases in temperature if present trends in greenhouse gas emissions continue. Increased temperatures of 2.7–4.4° C (5–8° F) relative to a baseline period 1970–1999 are expected to result in more days of zero or extremely low flows on Cienega Creek, especially at the lower end of the Cienega Creek Natural Preserve near Vail and in the Davidson Canyon watershed (USBR 2021).

The projected warming should favor continued expansion of the Sonoran Desert shrublands eastward across the Preserve, and further loss of the woodlands stranded high above the floodplain. Sonoran Desert species like *Encelia farinosa*, *Ambrosia deltoidea*, *Parkinsonia microphylla*, *Cottsia gracilis*, and *Carnegiea gigantea* can be expected to expand eastward across the Preserve. The Preserve is located where small shifts in temperature can greatly affect the risk and impacts of freezing. With continued warming, we may see a wider variety of Sonoran and tropical species colonize the terraces, canyon walls and uplands. In the bottomlands, species such as *Nicotiana glauca*, *Cenchrus ciliaris*, *Ambrosia monogyra*, *Ambrosia ambrosioides*, *Parkinsonia aculeata* and *Parkinsonia microphylla* might become more common and expand eastward.

The flow segments along Cienega Creek downstream of Davidson Canyon seem likely to run dry (U.S. Forest Service 2015), although segments upstream may fare better, particularly if Pima County can continue to discourage increased water use in the area or if exceptionally large floods periodically recharge the aquifer. Without the recharge effect of large flows or occasional wet monsoons, certain plant species, particularly wetland species may become rarer, and more transient under drier conditions.

While climate scenarios seem especially concerning for wetland species, most wetland plants observed in the Preserve during the "pluvial" period of 1986-1993 remain in the flora. Stromberg et al. (2009) noted a diverse soil seed bank in the Preserve that help wetland plants to re-establish in periodic wet years, despite ongoing drought. Some seeds are stored in the soil and some are imported with floodwaters. Numerous wetlands are also known to exist in the upper watershed (Wilson 2014, Wolkis 2016); these may serve to re-populate the Preserve when conditions are favorable.

That being said, we could expect that the abundance of wetland species with a perennial life cycle would drop sharply if all flows become more intermittent (Stromberg et al. 2005; Katz et al. 2011). Riverine areas of cattail and bulrush might give way to more mesic plant communities including *Muhlenbergia rigens* or *Sorghum halepense*, or a higher proportion of annual wetland species. Recruitment events for *Populus* and *Salix* could be unsuccessful if a high water table is not sustained long enough. The present *Populus fremontii* forest could be replaced by *Fraxinus velutina* and *Juglans major*.

The rate of soil loss in watersheds above the Preserve and elsewhere in southeastern Arizona is expected to double, mostly from areas of scrubland due to an increase in extreme rainfall events when compared to 1970 to 1999 conditions (Zhang et al. 2012). This could set the stage for an accumulation of clay and other sediment in the channel and floodplain that reduces the rate of infiltration to the floodplain aquifer and raises the channel-bed elevation, reducing the amount of aquatic habitat. The possible addition of mine-related watershed alterations could further curtail runoff to Cienega Creek downstream of Davidson Canyon (Powell et al. 2015), altering sediment transport. That being said, even in the wide floodplain near Vail where data are available (CMG Drainage Engineering 2016), I see no clear evidence for sustained aggradation or removal of sediment over the period 1986 to 2015.

Field observations suggest a continued increase in native and non-native grasses, shrubs, and herbs in areas where the floodplain can store additional sediment from nearby uplands, such as wide floodplains and at tributary confluences. *Prosopis velutina*, *Fraxinus velutina*, *Celtis reticulata*, *Ambrosia monogyra*, and exotic grasses are establishing in the modern floodplain. *Sorghum halepense* patches in the wider, sunny portions of Cienega Creek may expand. These changes could maintain frictional resistance to floodwaters, even if cottonwoods are further reduced by desiccation or large flood events.

Meanwhile, many of the post-1880 mesquite bosques stranded on the highest terraces 20 to 30 feet above the arroyo bottom will continue to transition toward creosote-dominated desertscrub. The high terraces will also continue to be eroded by the meandering streambed, creating new point bars susceptible to new riparian growth. Despite depletion of the aquifer during the 2002–2020 drought period, the water table remains suitable in many places for healthy canopy expansion of the *Prosopis velutina* trees that established during the wet period 1965–1993 on terraces that are only about ten feet above the reach of modern floodwaters.

The risk of fire in the Preserve is increasing with increased human use of the area, particularly after wet summers like 2021, which resulted in extensive grass cover near roadways. Areas of *Prosopis* die-back on high terraces and dense patches of perennial grasses

in the floodplain are vulnerable. The County's day-use recreational policy discourages campfires (which are illegal in the Preserve), but illicit activity, railroad sparks, roadway use, homeowner activities and lightning will inevitably cause fires. Some of these can be expected to burn areas of scrub or senescent *Prosopis* woodland, possibly enhancing the expansion of grasses and herbs at the expense of succulents, shrubs and trees.

CONCLUSIONS

Reduction of land-use stressors such as intensive livestock grazing and off-road vehicular activity, coupled with favorable climatic conditions, allowed the development of greater floodplain vegetation during the late twentieth century. Persistent drought is now reshaping the extent of riparian woodlands and forests, and non-native, perennial grasses are continuing to find new footholds. The review of species lost from the wet period of the 1980s to present does not suggest that the Preserve will necessarily lose overall species richness in coming decades, given the variability in microsites and microclimates afforded by this area, unless perennial flows are lost. Vegetation community extents and composition will continue to change in response to climate and land-use factors, particularly in the more dynamic bottomland settings.

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APPENDIX 1. PLANT PROFILES FOR THE CIENEGA CREEK NATURAL PRESERVE

Descriptions of the plants of the Preserve are given below, along with miscellaneous observations from decades of management. Species are native to the region unless indicated; introduced species are marked with an asterisk, *. Vouchers are cited following each entry; unless otherwise indicated, the specimens are located at the University of Arizona Herbarium (ARIZ). ASU is the Arizona State University Vascular Plant Herbarium; DES is Desert Botanical Garden; ASC is Deaver Herbarium at Northern Arizona University; NHI is the Natural History Institute Herbarium at Prescott College. Photographic vouchers are available through SEINet. Note that when JF is attached to the specimen number (e.g., *JF2013-*), the prefix is part of the collection record.

Table 4. Terms for distribution and abundance, modified from Makings (2006).

Abundant	Dominant or co-dominant in one or more habitats
Common	Easily seen in one or more habitats but not dominant in any
Occasional	Widely scattered but not difficult to find in the Preserve
Infrequent	Difficult to find in the Preserve, with few individuals or colonies
Rare	Very difficult to find in the Preserve, few individuals limited to one or very few locations or uncommon habitats. Does not refer to conservation status at large.
Not found	Previously documented in the Preserve, but not located between 2013 and 2021.

Table 5. Abbreviations for landscape settings are listed below.

Geomorphic site	Description
Aquatic, AQ	Areas of standing or running water in a stream channel at the time of the collection. Substrate texture varies from organic muck to gravel. Use CH or FP if the soil is merely moist.
Channel, CH	Areas of alluvium within the historic arroyo walls, which is subject to frequent scour and erosion during floods, but not with standing or running water at the time of collection. Soils are absent. Sediment texture varies from loose gravel to mud or even bedrock if on the floor of the channel. The distinction of channel from floodplain is restricted to Cienega Creek and Davidson Canyon.

Floodplain, FP	By definition, the floodplain is the area outside the lowest channel of Cienega Creek or Davidson Canyon. The floodplain is typically bordered by arroyo or canyon walls. The floodplain is an area of less frequent flow and lower velocity than the channel, often aggrading over time. Substrate is generally loose sand or mud without soil development, usually finer-grained than in the channel.
Wash, WA	Tributary floodplains and channel where the distinction between a channel and its floodplain was either not noted or no floodplain was present.
Holocene terrace, HT	Mesquite-covered Holocene fill terrace along Cienega Creek or Davidson Canyon. Area of pre-1880 floodplain, now isolated from flooding by arroyo incision. Consisting of brown silty or clayey loams, sometimes showing buried soils or soil development at the surface.
Pleistocene terrace, PT	Pleistocene terraces, physiographically higher than the Holocene terrace(s). Often these surfaces consist of a cobble cap overlying a reddened soil horizon. Soils usually thin but having some clay or carbonate in alluvium, often overlying bedrock.
Alluvial slope, AS	Hillslope or alluvial fan of Pleistocene alluvium, or colluvium, as distinguished from bedrock. Generally higher than Holocene arroyo or terrace. Soil development may include thick carbonate accumulations.
Rock outcrop, RX	When a plant is located directly on bedrock at any geomorphic position. Specimen label may include specific rock type.
Disturbed area, Di	Prefix applied to areas of evident mechanical disturbance on any geomorphic surface. Also used alone in reference to areas altered by historic land uses such as farming, housing or commerce, roads, utility rights-of-way, corralling livestock, trailheads and trails.

CHARAPHYCEAE

CHARACEAE

Chara sp. Muskgrass. Not a vascular plant, but a type of macro-alga; occasional; AQ. Stiff, submerged algal lifeform found in muddy-bottomed pools, included here for reference to aquatic conditions and because it can look like some other aquatic plants. Abundance is highly variable by year and season. Not included in species count. *JF2013-86*, *2015-524*

PTERIDOPHYTES

PTERIDACEAE

Astrolepis cochisensis (Goodd.) D. M. Benham & Windham. Cochise Scaly Cloak Fern. Perennial; infrequent; RX, HT. Occurs on rocky slopes on a variety of substrates, including alluvium and colluvium. *JF2013-11*, *JF2014-227*

Astrolepis sinuata (Lag. ex Sw.) D. M. Benham & Windham. Wavy Cloak Fern. Perennial;

rare; RX. Found in soil pockets on limestone. *2016-602*

Myriopteris lindheimeri (Hook.) J. Sm. Fairyswords. Perennial; rare; RX. Found on andesite. *2017-743*

Notholaena standleyi Maxon. Cloak Fern. Perennial; rare; RX. On andesite rock outcrops. May also be found on Pantano Formation. *2014-350*

GYMNOSPERMS

CUPRESSACEAE

Juniperus arizonica (R. P. Adams) R. P. Adams. Arizona Juniper. Tree; occasional; HT, FP, RX, AS, WA. Evidence of recruitment on floodplains, but not elsewhere. Many dead juniper trees on slopes, some possibly killed in the 1950s drought. Old trees sometimes have evidence of axe-work. *JF2013-147*

MAGNOLLIIDS

ARISTOLOCHIACEAE

Aristolochia watsonii Wooton & Standl. Pipevine. Root perennial; infrequent; FP, WA. *2014-321*

EUDICOTS

ACANTHACEAE

Anisacanthus thurberi (Torr.) A. Gray. Thurber Desert-Honeysuckle. Shrub; common; FP, RX, WA. Found mostly in ephemeral wash bottoms tributary to Cienega Creek, where it can be a prominent part of the riparian scrub community. *2014-285*

Carlowrightia arizonica A. Gray. Arizona Wrightwort. Subshrub; infrequent; RX, AS, WA. Often seen grazed. *2016-658*

Dicliptera resupinata (Vahl) Juss. Arizona Foldwing. Perennial; common; FP, HT, WA. One of the common groundcovers in low-energy floodplains and well-watered terraces of the Preserve, usually found with mesquite. It has increased since the removal of livestock. *2015-574*

Justicia longii Hilsenb. Long-Flowered Tubetongue. Perennial; rare; RX. Herb or subshrub found in sediment-filled nooks of andesite bedrock outcrops. *2017-744 ASU*

Ruellia ciliatiflora Hook. Hairyflower Wild Petunia. Perennial; occasional; HT, FP, WA. Root perennial emerging during the monsoons under the canopy of mesquite. This plant can grow in silty and clayey soils where soil moisture is held for long periods of time. *2014-418*

Tetramerium nervosum Nees. Hairy Fournwort. Perennial; rare; FP, WA. Found along frequently flooded, grassy channel banks of Davidson Canyon. *JF2013-194*

ADOXACEAE

Sambucus nigra L. Black Elder. Tree; infrequent; HT, FP. There does not appear to be any active recruitment of this species. There is one prominent tree in Davidson Canyon in open sun, but the rest are isolated amid stands of mesquite, usually where there is persistent moisture from a shallow water table. Some plants appear to have established in an older, higher channel, perhaps relics from a time in the early 1900s. This species was also planted at the Pantano Jungle restoration site from nursery stock. *2016-638*

AIZOACEAE

Trianthema portulacastrum L. Desert Horse-Purslane. Summer annual; occasional; FP, DiHT. *2016-707*

AMARANTHACEAE

Amaranthus fimbriatus (Torr.) Benth. ex S. Watson. Fringed Amaranth. Summer annual; infrequent; FP, DiFP. *2015-582*

Amaranthus palmeri Watson. Careless Weed. Summer annual; abundant; FP, DiFP, CH. *2014-383*

Atriplex canescens (Pursh.) Nutt. Four-Wing Saltbush. Shrub; common; DiHT, HT, WA. Planted from site-collected seed at Pantano Jungle restoration site. Also seeded in utility rights-of-way from unknown sources. *2014-313*

Atriplex elegans (Moq.) D. Dietr. Wheelscale Saltbush. Summer annual; occasional; HT, FP. Found especially in compacted soils. *JF2013-120*

Atriplex linearis S. Watson. Saltbush. Shrub; infrequent; HT. *JF2013-35*

Chenopodium berlandieri Moq. Pit-Seed Goosefoot. Summer annual; rare; AQ, CH. Found in well-watered reaches of Cienega Creek. *961*

Chenopodium fremontii S. Watson. Fremont Goosefoot. Summer annual; infrequent; HT. *2018-879*

Chenopodium incanum (S. Watson) A. Heller. Mealy Goosefoot. Summer annual; occasional; CH. Found alone Cienega Creek. *2014-324*, *2016-714*

Froelichia arizonica Thornb. ex Standl. Arizona Snake-Cotton. Taprooted perennial; rare; FP. Found along Cienega Creek south of I-10. *2015-548*

Gomphrena sonorae Torr. Sonoran Globe Amaranth. Summer annual; not found; CH. Detected once in the floodplain of Agua Verde Creek by Cowles *2008-09-22* (SEINet photo).

Guilleminea densa (Willd. ex Roem. & Schult.) Moq. Small Matweed. Summer annual, infrequent; RX. *JF2014-251*

**Salsola kali* L. Russian Thistle. Annual; common; DiFP, FP, RX. Herb mainly seen after wet winters or summers in disturbed areas. *2014-362*

**Salsola tragus* L. Prickly Russian Thistle. Annual; infrequent; DiCH, DiFP. *JF2013-185*

Tidestromia lanuginosa (Nutt.) Standl. Wooly Honeysweet. Summer annual; common; CH, FP, DiPT. *JF2013-108*

ANACARDIACEAE

Rhus microphylla Engelm. Little-Leaf Sumac. Shrub; occasional; HT, WA. Mostly occurs in the eastern half of the Preserve, including in areas cleared and burned in the 1970s. Planted at Pantano Jungle restoration site from site-collected seed. *2014-363*

APIACEAE

Berula erecta (Huds.) Coville. Cut-Leaf Water-Parsnip. Perennial; rare; AQ. Found after a major flood in summer 2020. *957*

Bowlesia incana Ruiz & Pav. Hoary Bowlesia. Winter annual; common; HT, WA. Can be abundant during a cool, moist spring in shaded areas. *JF2014-288*

Cymopterus multinervatus (J. M. Coult. & Rose) Tidestr. Grapeflower. Root perennial; infrequent; AS. *2016-622*

Daucus pusillus Michx. American Wild Carrot. Winter annual; occasional; FP, RX. *JF2014-270*

Lilaeopsis schaffneriana (Schltdl.) J. M. Coult. & Rose subsp. *recurva* (A. W. Hill) Affolter. Huachuca Water Umbel. Perennial; not found; AQ. Plants found in the Preserve were removed by flooding shortly thereafter. ima County may reintroduce the species, or it may colonize again someday from the upper watershed. *Titus 2001-05-01* (SEINet photo)

Spermolepis lateriflora G. L. Nesom. Rillito Valley Scaleseed. Spring annual; occasional; RX, FP, WA, AS. *2016-646*

APOCYNACEAE

Funastrum cynanchoides (Decne.) Schltr. Fringed Twinevine. Root perennial; common; HT, FP. Frequent in the mesquite bosques, especially those in the active floodplain. *2016-721, 2014-398*

Haplophyton cimicidum A.de Candolle. Cockroachplant. Subshrub; not found; RX. Seen only by Cowles *2004-09-26* (SEINet photo).

Matelea producta (Torr.) Woodson. Texas Milkvine. Root perennial; infrequent; HT. Usually an understory component of a mesquite woodland, but also seen in full sun in recovering clearings. *JF2013-126*

**Vinca major* L. Greater Periwinkle. Perennial; rare; HT. How this trailing vine came to inhabit a remote gully with no evidence of habitation is a mystery. My best guess is that the roots were planted when the area was inhabited in the late 1800s or early 1900s, though there is no nearby homestead. The plants have resisted several eradication efforts by County-sponsored summer youth and staff. Confined where it is, there is no chance that flooding could sweep the plants into the main channel, but the plants should be checked occasionally to see that they have not spread onto the main floodplain of Cienega Creek. *JF2013-71*

ASTERACEAE

Acourtia nana (A. Gray) Reveal & R. M. King. Dwarf Desert Peony. Perennial; occasional; PT, AS. Often found under the canopy of a mesquite tree. *2016-639*

Acourtia wrightii (A. Gray) Reveal & R. M. King. Perezia. Subshrub; occasional; PT, WA. More likely to be out in the open than the smaller *A. nana.* *2015-480*

Almutaster pauciflorus (Nutt.) Á. Löve & D. Löve. Alkali Marsh Aster. Perennial; rare; FP. Favors sunny, moist soil environments. *JF2013-89*

Ambrosia ambrosioides (Cav.) W. W. Payne. Canyon Ragweed. Shrub; infrequent. DiFP, WA. Found in the western half of the Preserve, where it is more common on tributaries than along Cienega Creek. The distribution in the Preserve may possibly be limited by frost. *JF2013-180*

Ambrosia confertiflora DC. Slim-Leaf Bursage. Perennial; common; DiPT, PT, RX. *JF2013-174, 2015-567, 2017-825.*

Ambrosia deltoidea (Torr.) W. W. Payne. Triangle-Leaf Bursage. Subshrub; rare; PT. Found only on a few south-facing slopes in the Preserve, but perhaps could increase under a warming climate. *2017-742*

Ambrosia monogyra (Torr. & A. Gray) Strother & B. G. Baldwin. Burrobrush. Shrub; abundant; CH, WA, FP. A dominant in some primarily ephemeral reaches, common in

sunny intermittent and perennial reaches. The plant is resilient to deposition and flooding. *JF2013-203*

Ambrosia psilostachya DC. Perennial Ragweed. Subshrub; occasional; DiFP, WA, CH, PT. Found in uplands as well as bottomlands. *2016-706*, *2017-796*; *Rainey 148 ASU*; *White & Shorrock 2005-09-03 ASU*

Artemisia ludoviciana Nutt. White Sagebrush, *Estafiate* (Spanish). Subshrub; occasional; RX, FP, AS. Found on rocks and alluvial substrates along the canyon bottoms. *2014-336*

Baccharis brachyphylla A. Gray. Short-Leaf False Willow. Shrub; rare; WA. Short-leafed, densely branched shrub of the eastern Preserve. *2017-814*

Baccharis salicifolia (Ruiz & Pav.) Pers. Seepwillow, *Batamote* (Spanish). Shrub; common; CH, WA. Occurs along ephemeral reaches, but is more common along perennial and intermittent reaches. No recruitment observed during intensive surveys. Recruitment in 2022 followed a large flood. *2016-692, 2016-710 ASU*, *2015-557*; *Rainey 97 ASU*

Baccharis sarothroides A. Gray. Desert Broom. Shrub; occasional; CH, FP, RX. Widespread pioneer shrub of ephemeral stream reaches. Bright green broom-like branches, resinous to the touch. *2017-752*; *White & Shorrock 2005-09-02 ASU*

Bahia absinthifolia Benth. Bahia. Perennial; common; PT, RX, HT, DiPT. A pioneer species in dry, disturbed soils. *JF2013-33*

Baileya multiradiata Harv. & A. Gray. Desert Marigold. Perennial; occasional; PT, DiAS, WA. Pioneer in disturbed areas. *2017-818*, *JF2013-181*

Baileya pleniradiata Harv. & A. Gray. Annual Desert Marigold. Annual; rare; Di, PT. Perhaps seeded on to right-of-way. *2019-931* (SEINet photo)

Bebbia juncea (Benth.) Greene. Sweetbush. Shrub; infrequent; WA, FP. An uncommon shrub of ephemeral washes in the western Preserve. *2017-800*

Bidens aurea (Aiton) Sherff. Arizona Beggarticks. Perennial; not found; CH. Found in moist soil environments. *Cowles 2004-09-30* (SEINet photo)

Bidens heterosperma A. Gray. Rocky Mountain Beggarticks. Summer annual; not found; FP. Observed in the Agua Verde confluence by *Cowles 2004-08-04* (SEINet photo)

Bidens laevis (L.) Britton, Sterns & Poggenb. Smooth Beggarticks. Summer annual; not found; AQ. Occurs in cienegas in upper watershed. Was common in 1991 but not in prior or subsequent years. *Fishbein 549*

Bidens leptocephala Sherff. Few-flowered Beggarticks. Summer annual; common; CH, FP, HT. Occupies much area after wet summers. *2015-573*

Brickellia baccharidea A. Gray. Resin-Leaf Brickellbush. Shrub; infrequent; HT, FP. *2014-410*

Brickellia coulteri A. Gray. Coulter Brickellbush. Shrub; common; RX. Found amongst dry, sunny rocks. *2014-438*, *JF2014-271*

Brickellia floribunda A. Gray. Chihuahuan Brickellbush. Shrub; occasional; FP, WA, RX. Found in shaded understory of cottonwood and mesquite forests in the modern floodplain of the main channel and its well-watered tributary confluences. *2015-597*

Calycoseris wrightii A. Gray. Desert Chicory. Winter annual; occasional; AS. Tends to grow within the branches of shrubs. *2014-276*

**Centaurea melitensis* L. Maltese Starthistle. Annual; not found; FP. Previously observed in the western portion of Cienega Creek amongst grasses. Found one plant in June 2022. *Cowles 2005-08-05* (SEINet photo)

Chaenactis carphoclinia A. Gray var. *carphoclinia.* Pebble Pincushion. Winter annual;

occasional; RX, AS, WA. *2016-682*

Chaenactis stevioides Hook. & Arn. Broadflower Pincushion. Winter annual; occasional; AS,WA, FP. *JF2014-241*, *JF2014-277*

Chloracantha spinosa (Benth.) G. L. Nesom var. *spinosa.* Spiny Aster. Root perennial; infrequent; CH, FP. An enormous stand under a powerline seems to have benefitted from increased sunlight after the cottonwoods were cut down by Tucson Electric Power. *2016-694*

Cirsium neomexicanum A. Gray. New Mexico Thistle. Biennial; infrequent; FP. Seemingly confined to floodplains. *2016-681*

Conyza canadensis (L.) Cronquist. Canadian Horseweed. Summer annual; infrequent; CH. Present at least since 1978 (Smith & Unangst 1987) but never common. Blooms in warm season. *2015-559*

Coreocarpus arizonicus (A. Gray) Blake. Arizona Coreocarpus. Perennial, rare, FP. Apparent after large flood. *2022-978* (SEINet photo)

Diaperia verna (Raf.) Morefield var. *verna*. Spring Pygmy-Cudweed. Annual; rare; FP, DiHT. *2019-924*

Dieteria asteroides Torr. Autumn False Tansy-Aster. Perennial; occasional; CH, FP, DiFP. Tolerates disturbed, compacted soils. *JF2013-119*; *Mauz 2004-120*

Dieteria bigelovii (A. Gray) D. R. Morgan & R. L. Hartm. Bigelow False Tansy-Aster. Biennial; not found; FP. *Cowles 2004-10-21* (SEINet photo)

Encelia farinosa A. Gray ex Torr. Brittlebush. Subshrub; occasional; AS, RX, DI. Found only on warmer, sunny microsites in the western half of the Preserve, may also have been seeded on disturbed rights-of-way. *JF2013-4*

Ericameria laricifolia (A. Gray) Shinners. Turpentine Bush, Pygmy Cedar. Subshrub; infrequent; RX. Found on sunny rock outcrops. *2014-327*

Ericameria nauseosa (Pall. ex Pursh) G. L. Nesom & G. I. Baird. Rubber Rabbitbrush. Shrub; rare; CH, WA. The few individuals tend to be hidden in stands of *Ambrosia monogyra* and *Baccharis*. *JF2014-236*; *Tlucek 2009-10-18 ASU*

Erigeron divergens Torr. & A. Gray. Spreading Fleabane. Annual; common; CH, FP. *2014-338*, *2016-684*; *Tlucek 2009-05-27*

Eriophyllum lanosum (A. Gray) A. Gray. White Wooly Sunflower. Annual; occasional; PT, AS. Found on dry, Pleistocene surfaces. *2016-649 ASU*

Gaillardia pulchella Foug. Blanketflower. Summer annual; rare; CH. A few isolated flowers at the margin of the flowing stream, in shade. *JF2013-14* (SEINet photo)

Gutierrezia microcephala (DC.) A. Gray. Small-headed Snakeweed. Subshrub; common; HT, DiHT Found on Holocene terraces and in disturbed areas. Abundance seems to have declined somewhat since the 1980s. This is the only snakeweed I found in the Preserve, despite years of looking for broader-headed *G. sarothrae*. I examined a packet specimen of a *Gutierrezia* at the ASU Herbarium, which I believe was misidentified as *G. sarothrae*. *JF2013-208*, *2014-420*, *2015-590*

Hedosyne ambrosiifolia (A. Gray) Strother. Ragged Marsh-Elder. Annual; rare; RX, CH. Found in channel in 2022 following large flood. *2014-428*

Helenium thurberi A. Gray. Thurber Sneezeweed. Annual; occasional; CH. Occurs in moist sand along the main channel, flowering in spring and summer, usually under the canopy of cottonwood trees. One of the syntypes of this species was collected at the cienega near Pantano Station in 1881. *JF2013-72*, *2014-332 ASU*

Helianthus annuus L. Common Sunflower. Annual; rare; CH. One individual flowering in Cienega Creek where a large pond had been created at the confluence of Agua Verde. *Alvarez 2019-06-07* (SEINet photo); *Rainey* (*156 ASU*)

Heliomeris longifolia (B. L. Rob. & Greenm.) Cockerell var. *annua* (M. E. Jones) Yates. Annual goldeneye. Annual; infrequent; CH, FP, HT. *2015-585*

Heterotheca subaxillaris (Lam.) Britton & Rusby. Camphorweed. Annual; not found; CH, DiFP. *Rainey* (*162 ASU*)

Heterotheca villosa (Pursh) Shinners. Hairy False Golden-Aster. Perennial; infrequent; WA, FP. *2014-293*

Hymenothrix wislizeni A. Gray. Trans-Pecos Thimblehead. Annual; infrequent; WA. Found in the eastern Preserve along Anderson Wash. *2017-821*

Isocoma tenuisecta Greene. Burroweed. Subshrub; common; DiHT. Usually occurring with mesquite and associated with past areas of disturbance. Abundance has declined in these and other areas of disturbance. *2014-395*

**Lactuca serriola* L. Prickly Lettuce. Annual; not found; CH. Several plants observed in 2022 after flood. One collection from moist cottonwood understory by Mauz (*2004-113*).

Laennecia coulteri (A. Gray) G. L. Nesom. Coulter's horseweed.Coulter Horseweed. Annual; infrequent; FP, DiHT. Abundance increased in aftermath of July 2021 flood. *2017-701*, *2019-876*

Lasthenia californica DC. ex Lindl. California Goldfields. Annual; not found; FP. Collected from perennial reach by Donna Shorrock (*2006-03-08 ASU*) and found in the seed bank by Stromberg et al. (2009).

Logfia filaginoides (Hook. & Arn.) Morefield. California Cottonrose. Annual; infrequent; RX. This flowered in January on a limestone outcrop. *2016-601*

Machaeranthera tagetina Greene. Mesa Tansyaster, *Flor de Capita* (Spanish). Annual; occasional; DIPT. This can be dominant in some patches on mechanically disturbed Pleistocene alluvial soils. *2015-552*

Machaeranthera tanacetifolia (Kunth) Nees. Tanseyleaf Tansyaster. Annual; occasional; FP, AS. *2014-425*, *2015-506*; *Cowles 2004-07-26* (SEINet photo)

Malacothrix fendleri A. Gray. Fendler Desert Dandelion. Annual; infrequent, FP. *2015-504*, *2016-674*

Malacothrix glabrata (A. Gray ex D. C. Eaton) A. Gray. Smooth Desert Dandelion. Annual; infrequent; FP. *2014-284*

Melampodium leucanthum Torr. & A. Gray. Plains Blackfooted Daisy. Perennial; occasional; RX, WA, AS. *2015-478*

Parthenium incanum Kunth. Mariola. Shrub; abundant; RX, AS, WA, FP, CH. Conspicuous shrub covering the uplands, less abundant in bottomlands. *2018-859*, *2015-570*

Pectis linifolia L. *Romero Macho* (Spanish). Annual; rare; CH. *2014-442*

Pectis papposa Harv. & A. Gray var. *papposa.* Chinchweed. Annual; occasional; FP, WA, CH, HT. Stromberg et al. (2009) noted this species was unique to ephemeral-flow sites during 2005 following a wetter winter. *2014-445*

Pluchea sericea (Nutt.) Coville. Arrowweed. Shrub; rare; FP, HT. The one stand of arrowweed may be a relict of the historic floodplain. The shrubs flower and fruit, but I have seen no evidence of establishment elsewhere in the Preserve. In the 1980s and 1990s, it grewon the high Holocene terrace, but by 2013 it covered the modern floodplain. Much of the floodplain patch was eroded in 2021. In 2016 (*Fonseca s.n.*) I

found a colony in an adjacent clay pit where I had never previously seen it. *JF2013-81, 2016-s.n.*

Porophyllum gracile Benth. *Hierba del venado* (Spanish), Odorata. Subshrub; occasional; RX, WA, PT. *JF2013-312*, *2014-452*, *2014-387*

Porophyllum ruderale (Jacq.) Cass. var. *macrocephalum* (DC.) Cronquist. *Yerba Porosa* (Spanish). Summer annual; infrequent; FP, HT. *JF2013-312*, *2014-38*, *2014-452*

Prenanthella exigua (A. Gray) Rydb. Brightwhite. Perennial; not found; FP. *Wright 1814-1*

Pseudognaphalium canescens (DC.) Anderb. Pearly Everlasting. Annual or perennial; occasional; CH. Found mostly in moist or shaded soil. *2014-333*, *2015-530*, *2016-688*

Pseudognaphalium leucocephalum (A. Gray) Anderb. *Gordolobo* (Spanish). Perennial; infrequent; FP. *Cowles 2004-08-29* (SEINet photo)

Pseudognaphalium stramineum (Kunth) Anderb. Cottonbatting Plant. Annual or biennial; infrequent; CH. *2018-846*

Psilostrophe cooperi (A. Gray) Greene. Paperflower. Subshrub; common; PT, DiAS. *JF2013-76*, *2014-248*

Rafinesquia californica Nutt. California Chicory. Winter annual; occasional; FP, HT. *2015-490*

Rafinesquia neomexicana A. Gray. Desert Chicory. Winter annual; common; FP. *2015-498*

Sanvitalia abertii A. Gray. Abert Creeping Zinnia. Summer annual; common; FP, HT, WA, RX. *2015-576*

Senecio flaccidus Less. var. *monoensis* (Greene) B. L. Turner & T. M. Barkley. Thread-leaf Ragwort. Subshrub; occasional; FP, WA. Found in open, sunny tributaries or confluence areas. *Cowles 2007-04-21* (SEINet photo), *2014-328*

**Sonchus asper* (L.) Hill. Spiny-Leaf Sow Thistle. Annual; occasional; CH. Found in wet channel of Cienega Creek. *JF215-95*, *2014-325*, *2014-335*

**Sonchus oleraceus* L. Common Sow Thistle. Annual or root perennial; rare; CH. Found in burned area. *2017-828*

Stephanomeria pauciflora (Torr.) A. Nelson. Few-flowered Wire Lettuce. Subshrub; infrequent; RX, AS. *JF2013-175*, *2015-495*

Stephanomeria tenuifolia (Raf.) H. M. Hall. Lesser Wire Lettuce. Perennial; occasional; WA, FP. *2014-315*, *2016-734*, *2017-798*

Symphyotrichum subulatum (Michx). G. L. Nesom var. *parviflorum* (Nees) S.D. Sundb. Annual Saltmarsh Aster. Summer annual; infrequent; AQ, CH, FP. Plants often show evidence of herbivory. *2017-723*, *2018-989*; *Murray 972*

**Taraxacum officinale* F. H. Wigg. Dandelion. Perennial; rare; AS. I found one specimen near Vail. *2019-928*

Thelesperma megapotamicum (Spreng.) Kuntze. Hopi Greenthread. Perennial; rare; RX, FP. Mainly on Pantano Formation in this area, resilient to flooding. *2015-528*

Thymophylla acerosa (DC.) Strother. Pricklyleaf Dogweed. Perennial; occasional; RX. *2015-457*

Thymophylla pentachaeta (DC.) Small. Five-Needle Pricklyleaf. Subshrub; occasional; CH, RX, DiAS. *2014-337*, *2017-754*

Tithonia thurberi A. Gray. Arizona Sunflowerweed. Summer annual; infrequent; FP, HT. Found in shady mesquite bosques and floodplains, in late summer and fall. *2014-401*, *2014-412*; *Fishbein 551*

Trixis californica Kellogg. *Hierba del pasmo* (Spanish). Shrub; infrequent; WA. Confined to

sunny sites in the western part of the Preserve. *JF2014-412*

Verbesina encelioides (Cav.) Benth. & Hook. f. ex A. Gray. Golden Crownbeard. Summer annual; occasional; CH, FP, AS. Mostly found in the eastern part of the Preserve, typically in dry, open floodplain of the main channel. *2015-585*, *2015-577 ASU, 2016-670*; *Mauz 2004-91*

Verbesina rothrockii B. L. Rob. & Greenm. Rothrock Crownbeard. Perennial; rare; RX. Found on outcrops of the Pantano Formation. *2016-739*

Viguiera dentata (Cav.) Spreng. var. *dentata*. Toothleaf Goldeneye. Subshrub; rare; FP. *2018-904*

Xanthisma spinulosum (Pursh) D. R. Morgan & R. L. Hartm. var. *chihuahuanum* (B. L. Turner & R. L. Hartm.) D. R. Morgan & R. L. Hartm. Lacy Sleepy Daisy . Perennial; common; AS, DiAS, CH, RX. Widely distributed, very common on rocky slopes. *JF2013-77*, *JF2014-278*

Xanthium strumarium L. Cocklebur. Summer annual; occasional; CH, FP. Found in sunny, frequently flooded parts of Cienega Creek, mixed with grasses, where past stream conditions have permitted mud deposition. *2017-805*

Zinnia acerosa (DC.) A. Gray. Desert Zinnia. Subshrub; common; PT, RX, CH. White-flowered shrub of dry uplands, but I have seen it attempt to colonize the main channel after late summer floods. *JF2013-1*, *2017-797*

BIGNONIACEAE

Chilopsis linearis (Cav.) Sweet subsp. *arcuata* (Fosberg) Henrickson. Desert Willow. Tree; occasional; CH, WA, FP, HT. Occurs primarily in the eastern portion of the Preserve, and along the Agua Verde in what I would call ephemeral reaches. One old tree on a terrace appears to be in a relictual channel, but otherwise these are in the modern floodplain. Also planted at the Pantano Jungle restoration site. *JF2013-127*, *2014-304*

BORAGINACEAE

Amsinckia intermedia Fisch. & C. A. Mey. *Cedkam* (O'odham), Fiddleneck. *JF2014-266*

Cryptantha barbigera (A. Gray) Greene. *Peluda* (Spanish). Winter annual; infrequent; FP. *2017-760*; *White 2005-06-14 ASU*

Cryptantha micrantha (Torr.) I. M. Johnst. var. *micrantha*. Redroot Cryptantha. Winter annual; infrequent; CH. *JF2013-52*

Cryptantha muricata (Hook. & Arn.) A. Nelson & J. F. Macbr. Prickly Cryptantha. Winter annual; not found; FP. *Wright 1815*

Cryptantha nevadensis A. Nelson & P. B. Kenn. Nevada Cat's-Eye. Winter annual; common; WA, HT, FP. *JF2015-489*

Cryptantha pterocarya (Torr.) Greene. Wingnut Cryptantha. Winter annual; occasional; CH, WA. *JF2015-651*

Eucrypta micrantha (Torr.) A. Heller. Desert Hideseed. Winter annual; common; CH, WA, DiAS. *JF2014-289*, *JF2014-250*

Harpagonella palmeri A. Gray. Palmer Grapplinghook. Winter annual; occasional; FP, HT. Slender spreading herb often found under mesquite trees. *2015-488*, *2016-616*

Johnstonella angustifolia (Torr.) Hasenstab & M. G. Simpson. Panamint Cryptantha. Winter annual; common; DiPT, AS, DiAS. *2015-512 ASU*, *2014-275*

Lappula occidentalis (S. Watson) Greene. Flatspine Stickseed. Winter annual; occasional;

FP, HT, CH. Found in sunny areas. *2015-466*

Nama hispida A. Gray. Bristly Nama. Winter annual; infrequent; CH, FP, DiFP. Flowering mainly in spring on sandy soils. *2017-788*, *2015-496*

Pectocarya recurvata I. M. Johnst. Curvenut Combseed. Winter annual; occasional; AS, DiHT, RX. *2015-474 ASU*, *2015-467*

Phacelia arizonica A. Gray. Arizona Scorpionweed. Perennial; occasional; CH. *JF2014-292*

Phacelia coerulea Greene. Skyblue Scorpionweed. Winter annual; occasional; RX, WA. Found in sandy or gravely soils. *JF2014-252*

Phacelia crenulata Torr. ex S. Watson var. *crenulata.* Notch-Leaf Scorpionweed. Winter annual; occasional; CH, FP, WA, AS, HT. Rhe most common *Phacelia* in the Preserve. *JF2014-255*

Phacelia crenulata Torr. ex S. Watson var. *ambigua* (M. E. Jones) J. F. Macbr. Purplestem Phacelia. Winter annual; common; FP. *JF2014-305*

Phacelia distans Benth. Distant Scorpionweed. Winter annual; infrequent; CH, FP. Found under bushes along sandy to gravely washes. *2016-669*

Tiquilia canescens (A. DC.) A. T. Richardson. *Hierba de la Virgin* (Spanish). Subshrub; common; DiFP, RX, AS. Found on dry slopes and terraces. *JF2013-199*

BRASSICACEAE

**Brassica tournefortii* Gouan. Sahara Mustard. Winter annual; rare; WA, FP, CH. Found in open, sandy soils. Noted by Theresa Wright in her 1996 observations of associated taxa. I have never noticed more than a few plants in any given year. *2016-625*

Caulanthus lasiophyllus (Hook. & Arn.) Payson. California Mustard. Winter annual; infrequent; AS. *JF2014-238*

**Chorispora tenella* (Pall.) DC. Common Blue Mustard. Winter annual; rare; FP. Found along Davidson Canyon. *2016-630*

Descurainia pinnata (Walter) Britton subsp. *glabra* (Wooton & Standl.) Detling. Smooth Western Tansy-Mustard. Winter annual; common; AS, RX, FP. *JF2014-247*

Descurainia pinnata (Walter) Britton subsp. *ochroleuca* (Wooton) Detling. Downy Western Tansy-Mustard. *2015-493*

Descurainia sophia* (L.) Webb ex Prantl. Fluxweed. Winter annual; infrequent; FP, CH.** *D. Bertelsen 2015-497*; *2015-463*

Hesperidanthus linearifolius (A. Gray) Rydb. Slimleaf Plains Mustard. Perennial; rare; WA. Tall, erect herb blends in with grasses. *JF2014-286*

Lepidium lasiocarpum Nutt. *Lentejilla* (Spanish). Winter annual; common; CH, WA. *2014-307*, *2017-758 ASU*

Lepidium oblongum Small. Veiny Pepperweed. Winter annual; infrequent; DiHT. *2015-465*

Lepidium thurberi Wooton. Thurber Pepperweed. Winter annual; infrequent; RX, FP. *JF2015-46*

Lepidium virginicum L. var. *virginicum.* Virginia Pepperweed. Winter annual; infrequent; DiHT. *JF2013-132*

**Matthiola parviflora* (Schousb.) W. T. Aiton. Winter annual; rare; WA, AS, CH, RX. *2016-623*

**Nasturtium officinale* W. T. Aiton. Watercress. Perennial; common; AQ. More abundant in wet winters, when flow is elevated. Found in the Preserve at least as far back as 1987 (Smith & Unangst 1987). *JF2013-97*

Physaria fendleri (A. Gray) O'Kane & Al-Shehbaz. Fendler Bladderpod. Perennial; infrequent; CH, FP, RX. *2015-487*

Physaria gordonii (A. Gray) O'Kane & Al-Shehbaz. Gordon Bladderpod. Perennial; common; RX. *JF2012-25*

Physaria purpurea (A. Gray) O'Kane & Al-Shehbaz. Rose Bladderpod. Perennial; infrequent; RX, FP. *JF2014-242*

**Sisymbrium irio* L. London Rocket. Winter annual; common; FP, HT. Often under cover of mesquite or other trees. *JF2016-605*

**Sisymbrium orientale* L. Indian Hedge-Mustard. Winter annual; rare; CH. *JF2015-469*

Streptanthus carinatus C. Wright ex A. Gray subsp. *arizonicus* (S. Watson) Kruckeb., Rodman & Worth. Lyreleaf Jewelflower. Annual; occasional; AS. This plant was common in spring 2019, when aphids attacked some plants. *JF2018-852*

Thysanocarpus curvipes Hook. Lacepod . Winter annual; infrequent; RX. *JF2014-253*

Tomostima cuneifolia (Nutt. ex Torr. & A. Gray) Al-Shehbaz, M. Koch & Jordon-Thaden. Wedge-Leaf Draba. Winter annual; common; RX, WA, CH. *2019-908*

CACTACEAE

Carnegiea gigantea (Engelm.) Britton & Rose. Saguaro. Stem succulent; occasional; RX, AS. Found mostly west of Davidson Canyon.

Coryphantha vivipara (Nutt.) Britton & Rose. Spinystar. Stem succulent; occasional; AS. *Rodden 2011-07-13*, *Rodden 2016-731* (SEINet photos)

Cylindropuntia acanthocarpa (Engelm. & J. M. Bigelow) F. M. Knuth var. *thornberi* (Thornb. & Bonker) Backeb. Thornber's Buckhorn Cholla. Stem succulent; occasional; PT, HT. *2014-974*, *2014-999* (SEINet photos)

Cylindropuntia fulgida (Engelm.) F. M. Knuth var. *fulgida*. Jumping Cholla. Perennial Stem succulent; occasional; DiPT, PT. This variety forms forests in the Preserve. *2019-946* (SEINet photo)

Cylindropuntia fulgida (Engelm.) F. M. Knuth var. *mamillata.* (Schott ex Engelm.) Backeb. Jumping Cholla. Stem succulent; infrequent; DiPT. Found in areas of previous disturbance. *JF2015-470* (SEINet photo)

Cylindropuntia leptocaulis (DC.) F. M. Knuth. Christmas Cholla. Stem succulent; common; DiHT, HT. *JF2014-219*

Cylindropuntia leptocaulis (DC.) F. M. Knuth × *C. versicolor* (Engelm. ex J. M. Coult.) F. M. Knuth. Hybrid Cholla. Perennial, Stem succulent; rare; FP. *2014-311* (SEINet photo); *Salywon 239 DES*

Cylindropuntia leptocaulis (DC.) F. M. Knuth × *C. spinosior* (Engelm.) F. M. Knuth. Hybrid Cholla. Stem succulent; infrequent; PT, FP. This putative hybrid is found in the eastern Preserve. *2015-511*, *2015-468 (*SEINet photo); *Salywon 239 DES*

Cylindropuntia spinosior (Engelm.) F. M. Knuth. Cane Cholla, Walkingstick Cactus. Stem succulent; occasional; DiHT, WA. *JF2015-513* (SEINet photo)

Cylindropuntia versicolor (Engelm. ex J. M. Coult.) F. M. Knuth. Staghorn Cholla. Stem succulent; infrequent; DiAS. *2019-05-04*, *2016-05-21* (SEINet photos)

Echinocereus engelmannii (Parry ex Engelm.) Lem. Engelmann Hedgehog Cactus. Stem succulent; occasional; RX, AS, PT. *2016-05-21, 2017-769* (SEINet photos)

Echinocereus fendleri (Engelm.) Sencke ex J. N. Haage. Pinkflower Hedgehog Cactus. Stem succulent; infrequent; AS. *2016-731* (SEINet photo)

Echinomastus erectocentrus (J. M. Coult.) Britton & Rose var. *erectocentrus*. Red-spined Fishhook Cactus. Stem succulent; occasional; AS, PT, HT. Unlike var. *acuñensis*, occurs 3,000 feet and higher. Present even on mechanically disturbed terrace. *Baker 13851*; *2016-699* (SEINet photo)

Ferocactus wislizeni (Engelm.) Britton & Rose. Fishhook Barrel Cactus. Stem succulent; common; HT, PT, DiPT. *2016-702* (SEINet photo)

Mammillaria grahamii Engelm. Graham Pincushion Cactus. Stem succulent; common; RX, AS. *JF2014-340* (SEINet photo)

Mammillaria heyderi Muehlenpf. Little Nipple Cactus. Stem succulent; not found; PT. *Baker 17248.2 ASU*

Opuntia engelmannii Salm-Dyck. Cactus Apple, Engelmann Prickly Pear. Stem succulent; abundant; DiPT, HT, RX. *2016-703*, *2018-841*, *2016-05-21* (SEINet photo)

Opuntia phaeacantha Engelm. Brown-spined Prickly Pear. Stem succulent; common; DiPT. *2018-842* (SEINet photo)

Peniocereus greggii (Engelm.) Britton & Rose. Arizona Queen of the Night. Stem succulent; rare; HT, AS. *2015-446* (SEINet photo)

CAMPANULACEAE

Nemacladus orientalis (McVaugh) Morin. Glandular Threadplant. Winter annual; infrequent; CH, WA. Look for this in early spring in bare sand or gravel. *2016-650*; *Cowles 2004-04-08* (SEINet photo)

Triodanis holzingeri McVaugh. Venus' Looking Glass. Annual; not found; CH, AQ. *Cowles 2007-04-21* (SEINet photo)

CANNABACEAE

Celtis pallida Torr. Spiny Hackberry. Shrub; infrequent; HT. Shrub found in shady mesquite thickets, mainly in eastern Preserve. *2014-351*

Celtis reticulata Torr. Canyon Hackberry. Tree; common; MT; FP. Tree or large shrub; common; HT; FP. Young trees establish in shaded areas. Also planted from seed-grown container stock at Pantano Jungle. *2017-786*

CARYOPHYLLACEAE

Silene antirrhina L. Sleepy Catchfly. Winter annual; infrequent; CH. *2017-746*

CLEOMACEAE

Polanisia dodecandra (L.) DC. subsp. *trachysperma* (Torr. & A. Gray) Iltis. Red-Whisker Clammyweed. Winter annual; common; CH, FP. *2014-298*; *JF2013-80*

CONVOLVULACEAE

Convolvulus equitans Benth. Gray Bindweed. Perennial; infrequent; CH. Found in bare, dry, main channel after late summer 2017 flood. *2018-855*

Evolvulus alsinoides (L.) L. Slender Dwarf Morning Glory. Perennial; infrequent; WA. *2014-394*

Evolvulus arizonicus A. Gray. Arizona Blue Eyes. Perennial; infrequent; WA. *2017-811*

Ipomoea costellata Torr. Crestrib Morning Glory. Summer annual; occasional; FP, HT, CH. *JF2013-375, 2014-413*

Ipomoea cristulata Hallier f. TranspecosTrans-Pecos Morning Glory. Summer annual; occasional; HT, FP. *JF2013-186*, *2018-843* (SEINet photo)

**Ipomoea hederacea* Jacq. Ivy-Leaf Morning Glory. Summer annual; occasional; CH, WA, RX. *2014-355*, *2014-417*, *2018-861*, *2017-819*

**Ipomoea purpurea* (L.) Roth. Tall Morning Glory. Summer annual; infrequent; RX. *2014-436*

Ipomoea ternifolia Cav. var. *leptotoma* (Torr.) J. A. McDonald. Three-Leaf Morning Glory. Summer annual; occasional; CH, FP. *2017-833*

CRASSULACEAE

Crassula connata (Ruiz & Pav.) A. Berger. Sand Pygmyweed. Winter annual; not found; CH, AS, DiPT. *Cowles 2005-04-02* (SEINet photo)

CUCURBITACEAE

Apodanthera undulata A. Gray. *Melon Loco* (Spanish). Perennial; infrequent; DiPT. Root-perennial, sprawling vine mainly found along the disturbed margin of the railroad right-of-way. *JF2013-140*

Cucurbita digitata A. Gray. Coyote Gourd. Perennial; infrequent; AS, PT, FP, WA. Sprawling vine found along Davidson Canyon as well as the mainstem floodplain. *2014-348*

Echinopepon wrightii (A. Gray) S. Watson. White Basal Apple. Summer annual; infrequent; FP. Vine found along tributaries, braided washes climbing a tree. *2016-726*

Marah gilensis (Greene) Greene. Wild Cucumber. Perennial; rare; HT. *2019-933*

Sicyosperma gracile A. Gray. Climbing Arrowheads. Annual; infrequent; FP. Vine found twining on mesquite during late monsoon season. *2016-720*; *Cowles 2004-08-27* (SEINet photo)

EPHEDRACEAE

Ephedra trifurca Torr. ex S. Watson. Long-Leaf Ephedra. Shrub; occasional; HT, FP. Stiff, erect shrub with long, green stems. Spring 2019 was marked by profuse and synchronous formation of cones. *JF2013-9*, *JF2014-221*

EQUISETACEAE

Equisetum laevigatum A. Braun. Smooth Horsetail. Perennial; common; AQ, CH. Increased or at least became more evident after removal of livestock and reduction of off-road vehicular activities. *JF2013-73*

EUPHORBIACEAE

Acalypha neomexicana Müll. Arg. New Mexican Copperleaf. Summer annual; occasional; WA. *2014-365*

Acalypha ostryifolia Riddell ex J. M. Coult. Hophornbeam Copperleaf. Summer annual; occasional; FP. *2015-575 ASU*, *JF2013-215*; *Mauz 2004-84*, *Mauz 2004-122*

Argythamnia serrata (Torr.) Müll. Arg. Sawtooth Ditaxis. Summer annual; infrequent; RX, AS. *2014-344*, *JF2013-141*, *2013-78*; *Rainey 130*

Croton pottsii (Klotzsch) Müll. Arg. Leatherweed. Perennial; common; DiAS, AS. *2014-352*

Croton texensis (Klotzsch) Müll. Arg. Texas Croton. Winter annual; not found; FP. *Cowles*

2004-04-18 (SEINet photo)

Euphorbia albomarginata Torr. & A. Gray. White-margined Sandmat. Perennial; occasional; CH. *JF2013-189*

Euphorbia capitellata Engelm. Head Sandmat. Perennial; infrequent; AS. *2016-647*

Euphorbia dentata* Michx. Toothed Spurge. Summer annual; not found; FP.** *Shorrock 2005-09-03 ASU*

Euphorbia indivisa Engelmann (Tidestrom) Royal Sandmat. Summer annual; occasional; FP. *2015-579*

Euphorbia florida Engelm. Chiricahua Mountain Sandmat. Summer annual; occasional; FP, HT WA. *JF2013-133*, *2014-399*, *2017-801*; *Shorrock 2005-09-03 ASU*

Euphorbia heterophylla L. Mexican Fireplant. Summer annual; infrequent; HT, FP. *Mauz 2004-82*; *JF2013-195*, *2014-386*, *2017-827*

Euphorbia hirta L. Pillpod Sandmat. Summer annual; infrequent; HT, CH, FP. *Rainey 155 ASU*, *2014-407*

Euphorbia hyssopifolia (L.) Small. Hyssopleaf. Hysoppleaf Sandmat. Summer annual; occasional; FP, WA, RX. *JF2013-202*, *2014-389*, *2014-358 ASU*; *Cowles 2004-08-27* (SEINet photo)

Euphorbia maculata L. Spotted Sandmat. Summer annual; common; AS. *JF2013-131*, *2014-326*

Euphorbia melanadenia Torr. Red-Gland Spurge. Perennial; infrequent; FP, RX, AS. *2015-571*, *2016-648*

Euphorbia micromera Boiss. Sonoran Sandmat. Summer annual; infrequent; HT. *2015-588*

Euphorbia pediculifera Engelm. *Golondrina* (Spanish). Annual; common; FP, WA, CH. *Rainey 159 ASU*; *2016-735Euphorbia polycarpa* Benth. Smallseed Sandmat. Perennial; occasional; WA, CH. *2014-379*, *2016-626*

Euphorbia serrula Engelm. Sawtooth Sandmat. Summer annual; occasional; AS, FP, HT. *2018-887; Rainey 130 ASU*; *Cowles 2004-07-26* (SEINet photo)

Euphorbia setiloba Engelm. ex Torr. Yuma Sandmat. Summer annual; infrequent; WA, CH, AS. *2014-378*, *2014-430*

Jatropha cardiophylla (Torr.) Müll. Arg. Limberbush, *Sangre del Drago* (Spanish). Subshrub; infrequent; AS, RX. This plant is restricted to the warmest sites, often on limestone in the western half of the Preserve. *2014-353*

Jatropha macrorhiza Benth. Ragged Nettle-Spurge. Root perennial; rare; HT. *2018-875*

FABACEAE

Acmispon brachycarpus (Benth.) D.D. Sokoloff. Foothill Deervetch. Winter annual; occasional; PT, AS, WA. *2015-476*

Acmispon strigosus (Nutt.) Brouillet. Hairy Deervetch. Summer annual; not found; FP. *Cowles 2004-04-02* (SEINet photo)

Amorpha fruticosa L. False Indigo Bush. Shrub; rare; FP. One plant, first noticed on October 4, 1992, survived a fire that swept the area in 2017. Several other patches became evident after the 2021 flood, or perhaps recruited. *JF2013-213*

Astragalus allochrous (M.E. Jones) Isely var. *playanus*. Halfmoon Milkvetch. Perennial; infrequent; DiHT. *2016-661*

Astragalus arizonicus A. Gray. Arizona Milkvetch. Perennial; rare; WA. *JF2014-290*

Astragalus nuttallianus DC. Small-Flowered Milkvetch. Annual; occasional; RX, WA, CH,

FP. *JF2014-258*

Astragalus wootonii Sheldon var. *wootonii*. Halfmoon Milkvetch. Perennial; infrequent; DiHT. *JF2016-661*

**Caesalpinia gilliesii* (Wall. ex Hook.) Wall. ex D. Dietr. Yellow Bird-of-Paradise. Shrub; rare; HT. One large clump located on terrace of Cienega Creek, showing no signs of spreading elsewhere. Did the heavy seeds come in during the construction of the power line? *2016-695*

Calliandra eriophylla Benth. Fairy Duster. Subshrub; common; RX, PT, AS. *JF2014-229*

Dalea formosa Torr. Featherplume. Subshrub; infrequent; RX. Mostly found on andesite. *2014-244*

Dalea nana Torr. ex A. Gray. Dwarf Prairie Clover. Perennial; rare; CH. *2018-837*

Dalea pogonathera A. Gray. Bearded Prairie Clover. Perennial; infrequent; RX, AS. *2016-599, 2014-419, 2016-640*

Dalea wrightii A. Gray. Wright Prairie Clover. Perennial; rare; DiAS. *2014-368*

Erythrina flabelliformis Kearney. Coral Bean. Perennial; not found; CH. Cowles observed that seedlings of this plant germinate in the channel, but are eliminated by frost. There are no known adult plants in the Preserve. *Cowles 2006-09-08* (SEINet photo)

Hoffmannseggia glauca (Ortega) Eifert. Hog Potato. Root perennial; infrequent; HT, DiHT. Found on poorly drained silt loams and clay loam soils of the Holocene terrace, especially in disturbed areas that receive extra runoff. *2015-543*; *Salywon 285 ASU*

Lupinus brevicaulis S. Watson. Shortstem Lupine. Winter annual; not found; FP. *Cowles 2005-04-23* (SEINet photo)

Lupinus concinnus J. Agardh. Bajada Lupine. Winter annual; infrequent; CH. *JF2014-291*

Lupinus sparsiflorus Benth. Desert Lupine. Winter annual; occasional; RX, CH. *JF2014-243, 2019-912*

**Melilotus albus* Medik. White Sweet-Clover. Winter annual; infrequent; FP. *2015-529*

**Melilotus indicus* (L.) All. Yellow Sweet-Clover. Winter annual; not found; CH. *Cowles 2007-04-22* (SEINet photo)

Mimosa aculeaticarpa Ortega var. *biuncifera* (Benth.) Barneby. Wait-a-Minute Bush. Shrub; rare; RX, FP. I tend to associate this plant with historically overgrazed areas, but here there are so few shrubs. *JF2013-151*

Mimosa dysocarpa Benth. Velvet-Pod Mimosa. Shrub; rare; DiFP. Only one specimen was found during the entire effort. *JF2014-402*

**Parkinsonia aculeata* L. Mexican Paloverde. Tree; rare; DiWA, DiAS, FP. Observed individuals are around six feet high, one in channel and two others in areas of disturbance. This species is more common along I-10; it has the potential for much increase during a warming climate. *2015-514*, *2017-782* (SEINet photo)

Parkinsonia florida (Benth. ex A. Gray) S. Watson. Blue Paloverde. Tree; common; PT, WA. Mostly in the western Preserve, with evidence of recruitment. *2014-294*

Parkinsonia microphylla Torr. Yellow Paloverde. Tree; common; PT, AS. The distribution of this plant is easiest to see in May when its blooms color the landscape near the Marsh Station Road bridge with yellow. Mature trees mainly found on the north side of the valley where saguaro co-occurs. This species is recruiting enthusiastically into new areas along Davidson Canyon. Does it reflect warmer temperatures? *2014-224*

Prosopis velutina Wooton. Velvet Mesquite. Tree; abundant; FP, HT, DiPT, RX. Many relictual trees on the high Holocene terrace (which was the pre-1880 floodplain) are

dying. Others are establishing and maturing in the active floodplain of Cienega Creek and its tributaries. One portion of the modern floodplain near Pantano was cut down for the wood in 1974, but the trees regrew. That same year another 60 acres of bosque was cleared with root plows and planted to Bermuda grass at the Pantano Jungle site. New plants germinated in the early 1980s and eventually found their roots into the water table. In the late 1990s, mesquite were planted on a portion of the same site. *JF2013-55, 2016-705*

Rhynchosia senna Gillies ex Hook. var. *texana* (Torr. & A. Gray) M.C. Johnst. Texas Snoutbean. Perennial; rare; HT, RX. Found in shaded rock alcoves twining on mesquite. *2016-724 ASU*

Senegalia greggii (A. Gray) Britton & Rose. [=*Acacia greggii* A. Gray]. Catclaw Acacia. Tree; occasional; FP, WA, HT. Tree or shrub, usually found with mesquite. *2014-295*

Senna covesii (A. Gray) H. S. Irwin & Barneby. Desert Senna. Subshrub; occasional; AS, DiAS. Mainly found along disturbed rights-of-way, where it may have been seeded. *JF2013-182, 2014-43*

Senna hirsuta H.S. Irwin & Barneby var. *leptocarpa* (Benth.) H.S. Irwin & Barneby. Wooly Senna. Root perennial; infrequent; FP. *2017-755*

Vachellia constricta (Benth.) Seigler & Ebinger. [=*Acacia constricta* Benth.]. Whitethorn Acacia. Shrub; common; FP, DiPT, RX. Common in uplands. Several were also planted from locally collected stock at Pantano Jungle. *2014-367, JF2013-105, 2015-459*

Vicia americana Muhl. ex Willd. American Purple Vetch. Perennial; infrequent; RX. *JF2014-439*

Vicia ludoviciana Nutt. ex Torr. & A. Gray subsp. *ludoviciana*. Louisiana Vetch. Annual; occasional; WA, FP, RX. *2015-484, 2017-750; Tluczek 2009-05-26 ASU*

FAGACEAE

Quercus turbinella Greene. Turbinella Sonoran Scrub Oak. Tree; rare; RX. Only a few relictual trees are on a hillslope of a tributary to Cienega Creek. No evidence of recruitment. *2017-741*

FOUQUIERIACEAE

Fouquieria splendens Engelm. subsp. *splendens*. Ocotillo. Shrub; common; AS, RX. There are many different age classes within the Preserve, including new seedlings. *2016-642*

GENTIANACEAE

Zeltnera calycosa (Buckley) G. Mans. Arizona Centaury. Winter annual; occasional; FP, AQ, CH. This plant was more frequent during the late 1980s and 1990s along moist streambanks, when canopy was more open and the water table higher. Many new plants evident in June 2022, especially along Davidson Canyon after recharge of the floodplain aquifer. *JF2013-69*

GERANIACEAE

**Erodium cicutarium* (L.) L'Hér. ex Aiton. Red Stem Filaree. Winter annual; occasional; RX, AS. When horses grazed Pantano Jungle site, this was a common spring herb. It was noted by Smith and Unangst (1987) but my sense is that this is less common now than in the mid- to late-1980s. *2016-652, JF2014-240, JF2013-20*

Erodium texanum A. Gray. Texas Filaree. Winter annual; infrequent; AS. *2016-652*; *Cowles 2005-03-18* (SEINet photo)

JUGLANDACEAE

Juglans major (Torr.) A. Heller. Arizona Walnut. Tree; occasional; FP, WA. Mostly found in the shade of other riparian trees. There is evidence of multiple recruitment events. This tree became much more common after removal of livestock. The first leaves are often killed by late frosts that settle into the valley. *JF2013-83*

KRAMERIACEAE

Krameria erecta Willd. ex Schult. Littleleaf Rhatany. Subshrub; common; AS. *2018-871*, *2015-540*

Krameria lanceolata Torr. Trailing Rhatany. Subshrub; occasional; AS. *2014-427*

LAMIACEAE

Hedeoma drummondii Benth. Drummond False Pennyroyal. Perennial; occasional; CH. *JF2013-41*

Hedeoma nana (Torr.) Briq. Dwarf Pennyroyal. Perennial; occasional; FP. *2013-04-02*, *2016-660 ASU*; *Cowles 2005-06-03* (SEINet photo)

**Lamium amplexicaule* L. Giraffehead. Winter annual; not found; FP. *Cowles 2005-02-08* (SEINet photo)

**Marrubium vulgare* L. Horehound. Subshrub; infrequent; DiHT. Found in areas of high former livestock disturbance.The abundance of this plant seems to have decreased over the decades. *JF2013-158*

Salvia columbariae Benth. Chia. Winter annual; occasional; HT, AS, RX. *JF2014-246*

Stachys coccinea Ortega. Scarlet Hedge Nettle. Perennial; infrequent; FP. *2015-544*; *Cowles 2008-08-16* (SEINet photo)

LINACEAE

Linum lewisii Pursh. BlueLewis Flax. Perennial; occasional; CH. *JF2013-66*, *JF2013-19 ASU*; *Rainey 95 ASU*

Linum pratense (Norton) Small. Meadow Flax. Winter annual; infrequent, RX, DiFP. *2016-643*, *2016-610*

Linum puberulum (Englem.) A. Heller. Plains Flax. Winter annual; infrequent; RX, WA. *2016-620*; *Cowles 2007-04-22* (SEINet photo)

**Linum usitatissimum* L. Cultivated Flax. Winter annual; rare; FP. *White s.n. ASU*; *2016-697*

LOASACEAE

Mentzelia affinis Greene. Yellow Comet. Winter annual; common; WA, FP. *2014-306*, *2015-520*, *2014-317*

Mentzelia albicaulis (Douglas) Douglas ex Torr. & A. Gray. Whitestem Stickleaf. *JF2014-249*

Mentzelia isolata Gentry. Arizona Blazingstar. Summer annual; infrequent; FP. *2018-896*

Mentzelia jonesii (Urb. & Gilg) H. J. Thomps. & J. E. Roberts. Jones Blazingstar. Spring annual; infrequent; RX. *JF2014-245*

Mentzelia multiflora (Nutt.) A. Gray. Adonis Blazingstar. Perennial; infrequent; RX. Found

on Pantano Formation mudstone. *2014-447*

LYTHRACEAE

Lythrum californicum Torr. & A. Gray. Native Loosestrife. Perennial; rare; CH. Found in moist soil environments; does not persist. *JF2013-93*

MALPIGHIACEAE

Cottsia gracilis (A. Gray) W. R. Anderson & C. Davis. Slender Janusia. Subshrub or vine; common; RX, AS. Found in central and western Preserve uplands. *2013-158*

MALVACEAE

Abutilon abutiloides (Jacq.) Garcke ex Hochr. Shrubby Indian Mallow. Subshrub; common; WA, PT/AS, RX. *JF2014-268*, *2014-391*, *2015-473*, *2019-945*, *2018-894*

Abutilon incanum (Link) Sweet. *Pelotazo* (Spanish). Subshrub; occasional; DiPT, HT. *2015-587*, *2015-553*

Abutilon malacum S. Watson. Yellow Velvetleaf Mallow. Subshrub; infrequent; FP, WA, RX. *2014-376*, *2014-216*

Abutilon mollicomum (Willd.) Sweet. Sonoran Velvetleaf Mallow. Subshrub; rare; RX. *2014-408*

Abutilon parvulum A. Gray. Dwarf Velvetleaf Mallow. Subshrub; infrequent; RX. *2018-882*

Anoda cristata (L.) Schltdl. Crested Anoda. Summer annual; infrequent; FP, HT. *2014-381*

Ayenia filiformis S. Watson. Trans-Pecos Ayenia. Subshrub; occasional; RX, AS. *2014-346*

Gossypium thurberi Tod. Thurber Cotton. Shrub; infrequent; WA, FP. *2014-303*

Hibiscus denudatus Benth. Rock Mallow. Subshrub; occasional; WA, AS. *2013-6*, *2014-393*

Rhynchosida physocalyx (A. Gray) Fryxell. Tuberous Sida, Buffpetal. Root perennial; common; DIHT, HT, FP. *2013-122*, *2014-361*

**Sida abutilifolia* Mill. Spreading Fanpetals. Perennial; common; DiHT, AS. *2016-675*, *2014-444*, *JF2013-138*; *Mauz 2004-103*

Sida neomexicana A. Gray. New Mexico Fanpetals. Perennial; not found; FP. *White & Shorrock 2005-09-03 ASU*

Sida spinosa L. Prickly Fanpetals. Subshrub; infrequent; DiAS. *2014-366*

Sphaeralcea emoryi Torr. ex A. Gray. Emory Globe-Mallow. Subshrub; infrequent; FP, DiPT. *2016-715*, *2015-592*

Sphaeralcea laxa Wooton & Standl. Caliche Globe-Mallow. Subshrub; common; RX, DiAS. *2013-129*

MARTYNIACEAE

Proboscidea altheifolia (Benth.) Decne. Yellow Devil's Claw. Root perennial; infrequent; DiPT, WA. Often found in areas previously disturbed by livestock corralling or domestic use. This is more prevalent than *P. parviflora* in the Preserve. *2013-142*

Proboscidea parviflora (Wooton) Wooton & Standl. Pink Devil's Claw. Annual infrequent; FP, HT. *Rainey 163 ASU*; *2018-890*

MOLLUGINACEAE

Mollugo verticillata L. Green Carpetweed. Summer annual; infrequent; DiPT, FP. The plant can cover the soil between perennials in and after wet summers like 2021. *2018-902*

MONTIACEAE

Calandrinia ciliata (Ruiz & Pav.) DC. Rock Purslane. Winter annual; not found; RX. *Cowles 2007-03-26* (SEINet photo)

Cistanthe monandra (Nutt.) Hershk. Common Mock Pussypaws. Winter annual; infrequent; RX. *2019-921*

MORACEAE

Morus microphylla Buckley. Texas Mulberry. Shrub; rare; WA, FP. Found in shaded, well-watered spots; no evidence of recruitment. *2016-65*

NYCTAGINACEAE

Allionia incarnata L. Trailing Windmills. Perennial; common; CH. *Rainey 120 ASU*; *White & Shorrock 2005-09-03 ASU*; *JF2013-153*

Boerhavia coccinea Mill. Scarlet Spiderling. Perennial; occasional; DiFP. *2018-900*, *2018-900*; *Cowles 2004-05-03* (SEINet photo)

Boerhavia coulteri (Hook. f.) S. Watson. Coulter's Spiderling. Summer annual; WA, FP. *Jf2013-177*

Boerhavia erecta L. Erect Spiderling. Summer annual; occasional; FP, HT. *Hazelton 106 ASU*; *2017-973* (SEINet photo)

Boerhavia intermedia M.E. Jones. Fivewing Spiderling. Summer annual; infrequent; CH. *2015-546*

Boerhavia megaptera Standl. Tucson Mountain Spiderling. Summer annual; not found; FP, WA. *Cowles 2004-08-27* (SEINet photo)

Boerhavia pterocarpa S. Watson. Apache Pass Spiderling. Summer annual; not found; CH, FP. *Cowles 2004-09-04* (SEINet photo)

Boerhavia wrightii A. Gray. Large-bracted Spiderling. Summer annual; common; DiAS, FP, PT. *2014-373*, *2014-382*, *2014-429*

Commicarpus scandens (L.) Standl. Climbing Wartclub. Shrub; occasional; WA, FP. Found in shaded margin of cottonwood groves, or tributary confluences, with other shrubs. *2014-316*, *2014-301*, *2019-943* (SEINet photo)

Mirabilis coccinea (Torr.) Benth. & Hook. f. Scarlet Four-O'clock. Perennial; rare; HT. *2015-491*

Mirabilis multiflora (Torr.) A. Gray. Colorado Four-O'clock. Perennial; infrequent; FP, HT. Found under tree canopy during monsoon season as a ground cover. *JF2013-117 ASU*, *2015-765*

OLEACEAE

Fraxinus velutina Torr. Velvet Ash. Tree; common; FP, CH. Found mainly as understory to mesquite and cottonwood in non-ephemeral reaches. This species has increased over the decades, and continues to recruit successfully. *2014-323*

**Ligustrum lucidum* W. T. Aiton. Glossy Privet. Shrub; rare; HT. Evergreen tree, a relict of cultivation and irrigation at a homestead. No evidence of spread. *JF2013-144*

Menodora scabra A. Gray. Twinberry. Shrub; occasional; RX, AS. *2016-664 ASU*

ONAGRACEAE

Chylismia claviformis (Torr. & Frém.) A. Heller. Browneyes. Spring annual; rare; WA. *Cowles 2009-04-06* (SEINet photo)
Eremothera chamaenerioides (A. Gray) W. L. Wagner & Hoch. Long-Capsule Mooncup. Winter annual; infrequent; FP. *2015-507*; *Wright 1813*
Eulobus californicus Nutt. ex Torr. & A. Gray. California Suncup. Spring annual; not found; WA. *Cowles 2005-03-24* (SEINet photo)
Oenothera curtiflora W. L. Wagner & Hoch. Velvetweed. Spring annual; occasional; CH. Found in moist soil environments. *2018-850*; *Cowles 2009-05-25* (SEINet photo)
Oenothera elata Kunth. subsp. *hookeri* (Torr. & A. Gray) W. Dietr. & W. L. Wagner. Hooker's Evening Primrose. Perennial; infrequent; FP. *Tluczek 2009-05-26 ASU*; *2015-558*; *Cowles 2007-07-31* (SEINet photo)
Oenothera primiveris A. Gray. Yellow Desert Evening Primrose. Winter annual; infrequent; FP. *2013-46*, *2013-27*, *2016-632*
Oenothera suffrutescens (Ser.) W. L. Wagner & Hoch. Scarlet Gaura. Perennial; infrequent; RX. *2015-494*

OROBANCHACEAE
Castilleja minor (A. Gray) A. Gray. Alkali Indian-Paintbrush. Winter annual; rare; FP. *Cowles 2007-04-29* (SEINet photo)
Orobanche cooperi (A. Gray) A. Heller. *Flor de Tierra* (Spanish). Root perennial; infrequent; FP. Parasitic on *Ambrosia monogyra*. *2015-516*

OXALIDACEAE
Oxalis albicans Kunth. Radish-Root Wood-Sorrel. Root perennial; infrequent; FP, WA. Usually in shaded understory. *2014-411*, *2015-510*

PAPAVERACEAE
Argemone gracilenta Greene. Sonoran Prickly-Poppy. Perennial; infrequent; FP. *2015-521* (SEINet photo)
Argemone ochroleuca Sweet. Pale Prickly Poppy. Winter annual; infrequent; CH. *2017-781 ASU*, *2015-503*
Argemone pleiacantha Greene. Southwestern Prickly-Poppy. Winter annual; occasional; CH. *2014-297*
Argemone polyanthemos (Fedde) G. B. Ownbey. White Prickly Poppy. Winter annual; infrequent; FP. *JF2013-198*
Corydalis aurea Willd. Scrambled Eggs. Winter annual; infrequent; spreading biennial herb with stems that have a watery liquid. *2013-47*
Eschscholzia californica Cham. subsp. *mexicana* (Greene) C. Clark. California Poppy. Winter annual; occasional; CH, AS, PT. *JF2013-42*

PASSIFLORACEAE
Passiflora mexicana Juss. Mexican Passionflower. Perennial; rare; FP. *2016-696*; *Cowles 2006-09-24* (SEINet photo)

PHRYMACEAE
Erythranthe guttata (DC.) G. L. Nesom. Common Monkeyflower. Perennial; common; AQ,

CH. This is one of the pioneer species after floods. *2015-536*, *2016-628*, *2016-685*

Erythranthe rubella (A. Gray) N. S. Fraga. Annual; rare; CH, AQ. Distribution is usually in higher elevation grasslands and mountain canyons in our area. *2017-751*

PHYTOLACCACEAE

Rivina humilis L. Rougeplant. Perennial; occasional; HT, RX. Found in very shady areas and near standing water. *JF2013-160*

PLANTAGINACEAE

Maurandya antirrhiniflora Humb. & Bonpl. ex Willd. Snapdragon Vine. Perennial; common; FP, RX. Vining herb with bluish-purple, snapdragon-like, flowers with a white throat. *White & Shorrock 2005-09-03 ASU*; *White 2005-06-15 ASU*; *2017-780*

Mecardonia procumbens (Mill.) Small. Mock Monkeyflower. Perennial; rare; CH. Found in moist soil environment. *2018-847*; *Cowles 2007-04-22* (SEINet photo)

Nuttallanthus texanus (Scheele) D. A. Sutton. Texas Toadflax. Winter annual; not found; CH. *Cowles 2007-03-18* (SEINet photo)

Penstemon parryi (A. Gray) A. Gray. Parry Penstemon. Perennial; infrequent; RX. Found on andesite with other Sonoran species. *JF2014-254*

Plantago ovata Forssk. Blond Plantain, Desert Indianwheat. Winter annual; common; RX, AS, CH. *JF2014-259*, *2016-621*; *Rainey 63 ASC*

Plantago patagonica Jacq. WoollyWooly Plantain. Winter annual; occasional; RX. *JF2014-261*

Plantago rhodosperma Decne. Red-Seed Plantain. Winter annual; rare; CH. *JF2019-941, Cowles2007-04-22* (SEINet photo)

Schistophragma intermedium (A. Gray) Pennell. Harlequin Spiralseed. Winter annual; rare; CH. *JF2017-830*

**Veronica anagallis-aquatica* L. Blue Water Speedwell. Perennial; abundant; AQ. *JF2013-68*

Veronica peregrina L. Neckweed. Winter annual; infrequent; AQ; CH. Found on bare, moist soil. *2019-911*; *Cowles 2007-04-01* (SEINet photos)

PLATANACEAE

Platanus wrightii S. Watson. Arizona Sycamore. Tree; infrequent; FP, CH. Deciduous tree found in canyon settings, mixed in with other broadleafed trees. *2016-722 ASU*, *2016-722*

PLUMBAGINACEAE

Plumbago zeylanica L. Wild Leadwort. Subshrub; rare; FP/WA. *Cowles 2004-05-29* (SEINet photo)

POLEMONIACEAE

Eriastrum diffusum (A. Gray) H. Mason. Miniature Woolystar. Winter annual; occasional; PT, AS. *JF2014-262*

Gilia flavocincta A. Nelson. Lesser Yellowthroat Gilia. Winter annual; rare; FP. *2016-637*

Gilia sinuata Douglas ex Benth. Rosy Gilia. Winter annual; infrequent; WA, AS. *JF2013-51*

Gilia stellata A. Heller. Star Gilia. Winter annual; occasional; DiHT, RX, CH. Found on

alluvium as well as Pantano Formation. *JF2014-282*, *2015-519*, *JF2013-48*

Ipomopsis longiflora (Torr.) V.E. Grant subsp. *australis* R.A. Fletcher & W.L. Wagner. Whiteflowered Trumpet. Winter annual; infrequent; DiAS, FP. *2014-320*; *Rainey 129*

Linanthus bigelovii (A. Gray) Greene. Bigelow Desert-Trumpet. Winter annual; not found; FP. *Cowles 2005-03-10,* (SEINet photo)

POLYGALACEAE

Polygala alba Nutt. White Milkwort. Perennial; rare; FP. *2017-762*

Polygala barbeyana Chodat. Blue Milkwort. Subshrub; infrequent; DiAS. *2014-370*

Polygala macradenia A. Gray. Glandleaf Milkwort. Subshrub; infrequent; AS, RX, HT. Growing like a bonsai on the most exposed, limy alluvial slopes and in the Pantano Formation itself. *JF2013-178*, *2018-872*

Polygala obscura Benth. Velvetseed Milkwort. Perennial; rare; RX. *2014-565*

POLYGONACEAE

Eriogonum abertianum Torr. Abert's Buckwheat. Annual; common; WA, CH, DiAS, RX, FP. This is the most common and widespread *Eriogonum* in the Preserve. It pioneers bare ground. *2014-369*

Eriogonum capillare Small. San Carlos Buckwheat. Winter annual; infrequent; CH. *2016-673*; *Cowles 2005-05-14* (SEINet photo)

Eriogonum deflexum Torr. var. *deflexum*. Flat-crown Buckwheat. Winter annual; common; CH, WA, RX. *JF2014-267*; *White 1814*

Eriogonum palmerianum Reveal. Skeleton Weed. Summer annual; infrequent; WA. *2017-804 ASU*

Eriogonum polycladon Benth. Sorrel Buckwheat. Summer annual; not found; FP. *Cowles 2004-10-24* (SEINet photo)

Eriogonum trichopes Torr. Little Desert-Trumpet. Winter annual; occasional; FP, WA. *Tluczek 2009-05-27 ASU*; *2014-299*

Eriogonum wrightii Torr. ex Benth. Shrubby Buckwheat. Subshrub; occasional; RX. *2014-414*, *2014-421*, *2015-568*

Persicaria punctata (Elliott) Small. Dotted Smartweed. Root perennial; rare; FP. Herb of moist seeps. *2016-719 JF2013-191*, *2014-341*, *2018-878*

Portulaca umbraticola Kunth subsp. *umbraticola*. Wing-Pod Purslane. *White & Shorrock 2005-09-03 ASU*

PORTULACACEAE

Portulaca halimoides L. Silk-Cotton Purslane. Summer annual; not found; FP, CH. *Cowles 2005-09-12* (SEINet photo)

Portulaca oleracea L. *Verdolaga* (Spanish). Summer annual; infrequent; FP, CH, WA. *2014-380*

Portulaca suffrutescens Engelm. Shrubby Purslane. Root perennial; common; PT, RX, FP, CH.

**Polygonum argyrocoleon* Steud. ex Kunze. Silver-sheath Knotweed. Winter annual; infrequent; CH, AQ. Wet streamsides, uncommon and not persisting year to year. *2019-906*, *2016-683*

Rumex altissimus Alph. Wood. Smooth Dock. Root perennial; common; HT, FP. Herb of

silty soils (usually the Holocene terraces). *2014-461*, *2016-636*, *2016-718*

**Rumex crispus* L. Curly Dock. Root perennial; rare; CH. *964*

Rumex hymenosepalus Torr. Canaigre. Root perennial; occasional; HT, FP. *Cowles 2005-03-19* (SEINet photo); *2016-659*

PRIMULACEAE

Androsace occidentalis Pursh. Western Rock-Jasmine. Winter annual; WA, HT. *Rainey 71 ASU*, *Cowles 2005-04-03* (SEINet photo).

RANUNCULACEAE

Anemone tuberosa Rydb. Desert Anemone. Root perennial; common; RX, AS. Herb of the upland slopes and terraces. *JF2013-26*

Aquilegia chrysantha A. Gray. Golden Columbine. Root perennial; rare; FP. Seen only once, May 8, 1993, the columbine was growing a sloping stream bank right next to the active channel, under the shade of mature cottonwoods. *1993-05-08* (SEINet photo)

Clematis drummondii Torr. & A. Gray. Virgin's Bower. Perennial; common; HT. Perennial vine of the mesquite bosque and floodplains, increasing in visibility after livestock were removed from the Preserve. *2014-314*, *2016-698*

Delphinium scaposum Greene. Bare-stemmed Larkspur. Root perennial; infrequent; AS. *2016-644*

RESEDACEAE

Oligomeris linifolia (Vahl) J. F. Macbr. Cambess, Oligomeris. Winter annual; infrequent; CH. Found on bare sand bars. *JF2013-49*

RHAMNACEAE

Condalia warnockii M. C. Johnst. var. *kearneyana.* M. C. Johnst. Warnock Condalia. Shrub; occasional; AS. Spiny shrub occurring in uplands. *2014-349*

Frangula californica (Eschsch.) A. Gray. California Buckthorn. Shrub; rare; FP. This durable shrub is found in the shade of hackberry and mesquite. *2017-793*, *2018-856*

Ziziphus obtusifolius (Hook. ex Torr. & A. Gray) Hauenschild. Graythorn. Shrub; common; FP, HT, DiHT, AS. Found on mesquite-dominated terraces, including those that were previously mechanically cleared. *Rainey 106 ASU*; *JF2013-207*

RUBIACEAE

Galium aparine L. Common Bedstraw. Winter annual; infrequent; FP, HT. Found in the shade of other plants, near cliff edges and other moist places. *2014-450*

Galium microphyllum A. Gray. Bracted Bedstraw. Perennial; infrequent; FP, AS. *Shorrock 2006-03-08*; *2019-927* (SEINet photo)

RUTACEAE

**Ruta graveolens* L. Common Rue. Perennial; single plant observed until 2004, no longer found; FP. *Tedford 1994-05-26*

Thamnosma texana (A. Gray) Torr. *Hierba del Venado* (Spanish). Perennial; infrequent; CH, WA. Found on limy substrates. *2015-483*

SALICACEAE

Populus fremontii S. Watson subsp. *fremontii*. Frémont Cottonwood. Tree; common; CH, FP. There were few, mostly old cottonwood trees in 1986. The 1964 aerial photographs show no cottonwood forest was present at that time. Most cottonwoods in the Preserve recruited in 1984 following a major flood. During the period 2013–2019, I observed only recruitment of this species, during 2017, which was unsuccessful. *2017-790, 2016-611*

Salix bonplandiana Kunth. Bonpland Willow. Tree; not found; CH. There was one tall specimen of this tree in 1986, and it is no longer extant. *Mauz 2004-92*

Salix gooddingii C. R. Ball. Goodding Willow. Tree; common; CH, FP. This was the dominant broadleaf riparian tree of the perennial reaches in the early 1980s. At times there are heavy infestations of caterpillars in the trees. Goodding willow roots extends under the wetted channel and along the banks where the water flows, helping provide cover for fish and macroinvertebrates. If there was successful recruitment during 2013–2019, I missed it. *JF2013-40*

Salix taxifolia Kunth. Yew-Leaf Willow. Tree; not found; FP. Formerly occurred in one location upstream of I-10, no longer extant. A potential source population occurs in Davidson Canyon upstream of I-10. *Rainey 102 ASU*

SANTALACEAE

Phoradendron californicum Nutt. Desert Mistletoe. Shrub; occasional; parasite. Found in leguminous trees, especially mesquite. Was uncommon until drought of early 2000s. *JF2013-5*

Phoradendron leucarpum (Raf.) Reveal & M.C. Johnst. Christmas Mistletoe. Shrub; occasional; parasite. Found in the canopy of cottonwood and ash trees. *JF2013-88*

SAPINDACEAE

Sapindus saponaria L. var. *drummondii* (Hook. & Arn.) L. D. Benson. Soapberry. Tree; rare; RX, FP. *Murray 2021-976*

SAURURACEAE

Anemopsis californica (Nutt.) Hook. & Arn. *Yerba Mansa* (Spanish). Root perennial; infrequent; CH, AQ, FP. Found in moist soil environments. *2016-679*

SOLANACEAE

Calibrachoa parviflora (Juss.) D'Arcy. Small-flowered Petunia. Winter annual; rare; WA. *2014-329*

Chamaesaracha coronopus (Dunal) A. Gray. Greenleaf Five-Eyes. Perennial; rare; DiHT. *2016-704*

Chamaesaracha sordida (Dunal) A. Gray. Hairy Five-Eyes. Perennial; occasional; DiHT, DiAS. Seems to persist longer than most other plants as an indicator of disturbance. *JF2013-200, JF2014-283, 2014-343, 2014-374.*

Datura discolor Bernh. Desert Thornapple. Summer annual; occasional; FP, CH, HT. *2014-384*

Datura quercifolia Kunth. Oak-Leaf Datura. Summer annual; rare; HT. *2014-449*

Datura wrightii Regel. Sacred Datura. Root perennial; common; FP. *Rainey 157 ASU*; *2016-671*

Lycium andersonii A. Gray. Desert Wolfberry. Shrub; occasional; HT, DiPT. *JF2013-139*, *2014-441*

Lycium berlandieri Dunal. Berlandier Wolfberry. Shrub; rare; HT. Found in mesquite bosque. *Rainey 108*

Lycium exsertum A. Gray. Arizona Wolfberry. Shrub; occasional; WA, HT. Look for this in the warmer, Sonoran tributaries of the western Preserve. *2016-608*, *2016-609*, *2016-606*

Lycium pallidum Miers. Pallid Wolfberry. Shrub; occasional; WA, HT. This wolfberry prefers the silt loam of the Holocene terraces and modern alluvial fans developed on terraces. Often growing with sacaton and mesquite in the eastern (Chihuahuan) part of the Preserve. *2016-677*

**Nicotiana glauca* Graham. Tree Tobacco. Shrub; infrequent; WA, FP. A relatively recent invader of the main channel of Cienega Creek and Agua Verde Wash. Its distribution is limited by frost and floods. *2014-308*

Nicotiana obtusifolia M. Martens & Galeotti. Desert Tobacco. Perennial; occasional; FP, HT, RX. Short, perennial herb, often in areas shaded by mesquite or rock. *Rainey 164*; *White 2005-6-15 ASU*; *2014-406*

Physalis acutifolia (Miers) Sandwith. White-flowered Groundcherry. Perennial; rare; RX. *2014-339*

Physalis hederifolia A. Gray var. *fendleri* (A. Gray) Cronquist. Ivy-Leaf Groundcherry. Perennial; infrequent; DiPT, DiRX. *2014-24*, *2015-554*, *2014-347*

Physalis pubescens L. Yellow Groundcherry. Summer annual; occasional; HT, RX, DiFP, RX. HT. *Rainey 118 ASU*

Physalis solanacea (Schltdl.) Axelius. Netted Globecherry. Summer annual; not found; FP. *Cowles 2005-09-05* (SEINet photo)

Solanum americanum Mill. Black Nightshade. Perennial; rare; HT. In shaded areas with mesquite. *2014-409*

Solanum douglasii Dunal. Green-Spot Nightshade. Perennial; infrequent; CH, FP. Found in well-watered places along Cienega Creek. *2015-545 ASU*

Solanum elaeagnifolium Cav. Silver-Leaf Nightshade. Perennial; occasional; DiHT, DiPT, FP. Primarily occupying mechanically disturbed terraces which had been cleared of mesquite. My impression is that the distribution and frequency of occurrence has shrunk over the past 30 years. *2013-137*

Solanum rostratum Dunal. Buffalobur. Summer annual; not found; FP. Observed by Cowles (*2005-09-05,* SEINet photo) in the main channel of Cienega Creek. *Cowles 2005-09-05* (SEINet photo)

TALINACEAE

Talinum paniculatum (Jacq.) Gaertn. Jewels of Opar. Root perennial; rare; PT. Found under other shrubs. *2016-712*

TAMARICACEAE

**Tamarix chinensis* Lour. Saltcedar, Tamarisk. Tree; occasional; FP, WA, CH. Found primarily along the main stem of Cienega Creek, especially where soil or bedrock is alkaline. According to resident Diane Hanna, there were no tamarisk in the channel prior to the 1983 flood (personal communication, Jan. 20, 1994). During the late 1980s, I used to see vast numbers of seedlings germinating on muddy sand bars during each monsoon

season. Since 1989, a few plants have established on Davidson Canyon, mostly where there are outcrops of the Pantano Formation. During intensive field survey, I saw only one recruitment event, following a large, late summer 2017 flood. More recruitment occurred after the July 2021 flood. *JF2013-57*; *Mauz 2004-79*

URTICACEAE

Parietaria hespera B. D. Hinton var. *hespera*. Rillita Pellitory. Winter annual; rare; WA. Found under shady rock overhangs. *2016-654*

VERBENACEAE

Aloysia wrightii (A. Gray ex Torr.) A. Heller. Wright Lippia. Shrub; infrequent; HT, RX. Occasionally found in channel after floods. *2015-569*; *Mauz 2004-80*

Glandularia bipinnatifida (Nutt.) Nutt. var. *latilobata* (L. M. Perry) B. L. Turner. Broad-lobed Mock Vervain. Perennial herb; infrequent; FP. Found in muddy backwater areas. *2015-533*

Verbena bracteata Cav. ex Lag. & Rodr. Bracted Vervain. Winter annual; rare; FP. Found on sand bars and backwaters. *2015-538*

Verbena gracilis Desf. Fort Huachuca Vervain. Perennial; not found; FP. Last seen in an ephemeral reach downstream of Marsh Station Road in 2006. Also found in the seedbank study of Stromberg et al. (2009). *Hazelton 123 ASU*

Verbena menthifolia Benth. Mint Vervain. Perennial; rare; FP. Found under broad-leaf riparian trees, flowering in April. *2017-756*

Verbena pinetorum Moldenke. Chihuahuan Vervain. Perennial; infrequent; FP, CH. This is the most common *Verbena* in the Preserve. *2015-537*

VIOLACEAE

Hybanthus verticillatus (Ortega) Baill. Babyslippers. Subshrub; infrequent; PT, AS. *2016-700 ASU*, *2014-453*

VITACEAE

Cissus trifoliata (L.) L. Arizona Grape-Ivy. Root perennial; infrequent; FP, HT. This vine seemed to become more numerous and widely distributed in the 1990s after the removal of livestock. *2014-453*

Vitis arizonica Engelm. Arizona Grape. Perennial; rare; FP. No evidence of recruitment during the term of this study. *2019-932*

ZYGOPHYLLACEAE

Kallstroemia californica (S. Watson) Vail. California Caltrop. Summer annual; rare; AS. *JF2013-179*

Kallstroemia grandiflora Torr. ex A. Gray. Arizona Poppy. Summer annual; occasional; WA. Found in areas of riparian scrub at tributaries, especially during exceptionally wet summer and fall. Outside the Preserve, I have seen it on disturbed alluvial slopes. *JF2013-163*

Kallstroemia parviflora Norton. Warty Caltrop. Summer annual; infrequent; FP. *JF2013-110*

Larrea tridentata (DC.) Coville. Creosote Bush. Shrub; abundant; HT, AS, PT, RX. New individuals establish on alluvial slopes and disturbed areas during wet summers. *JF2013-*

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**Tribulus terrestris* L. Goathead, Puncturevine. Summer annual; rare; CH. Found in Davidson Canyon. *JF2013-190*

MONOCOTS

AMARYLLIDACEAE

Allium macropetalum Rydb. Large-Flowered Onion. Root perennial; rare; RX. This bulb is found in nooks in the andesite bedrock. *JF2014-257*

ARACEAE

Lemna sp. Duckweed. Perennial; occasional; AQ. This floating aquatic plant of ponds or slow-moving waters is scarce some years, common others. *2016-687*

ASPARAGACEAE

Agave palmeri Engelm. Palmer Agave. Leaf succulent; occasional; PT, RX. This is the dominant agave of the Preserve, primarily found on Pleistocene terraces of Cienega Creek and Davidson Canyon. *2017-824*; see also *Hodgson 30535* and *30533*.

Dasylirion wheeleri S. Watson. Desert Spoon, *Sotol* (Spanish). Leaf succulent; occasional; AS, PT, RX. Succulent of hillslopes or rocky outcrops. *2018-840* (SEINet photo)

Dichelostemma capitatum (Benth.) Alph. Wood subsp. *pauciflorum* (Torr.) Keator. Bluedicks. Root perennial; occasional; HT, AS. *JF2013-18*

Yucca baccata Torr. var. *brevifolia* L. D. Benson & Darrow. Banana Yucca. Leaf succulent; infrequent; AS, PT. This yucca bears large flowers, but seldom bears fruit in the Preserve. They flowered profusely in spring 2019, the first big bloom during the period of observation 2013–2019. *2016-05-21* (SEINet photo)

Yucca elata (Engelm.) Engelm. Soaptree Yucca. Leaf succulent; occasional; PT, HT, AS. Found on alluvial slopes, and on terraces with mesquite and grass. *2018-838* (SEINet photo)

COMMELINACEAE

Commelina erecta L. White-Mouth Dayflower. Root perennial; infrequent; FP. *JF2013-107*, *JF2013-118*

CYPERACEAE

Carex ultra L. H. Bailey. Cochise Sedge. Perennial; infrequent; CH, FP. Found in areas of moist soil, usually under shade. This species increased after removal of livestock. Plants observed to have survived a fire. *Wright 1822 ASU*; *Mauz 2004-117*; *White, Shorrock, & Hazelton 2005-06-16*

Cyperus esculentus L. Yellow Nutsedge, *Chufa* (Spanish). Perennial; rare; DiFP, FP. *2017-810*; *Cowles 2004-08-27* (SEINet photo)

Cyperus odoratus L. Fragrant Flatsedge. Annual; rare; AQ. *2018-899*

Cyperus squarrosus L. Bearded Flatsedge. Annual; not found; AQ. *Cowles 2004-09-16* (SEINet photo)

Eleocharis montevidensis Kunth. Sand Spikerush. Perennial; infrequent; AQ. Erect, mat-forming graminoid. *2017-791*; *Wright 1819*; *Turner 78-51*.

Schoenoplectus americanus (Pers.) Volkart ex Schinz & R. Keller. Chairmaker's Bulrush.

Perennial; common; CH, AQ. Plants mainly evident in the warm season. In wet years, this plant can create dense patches of reeds. When the floods come, the reeds fold flat against the channel and can armor it against erosion. The species was heavily grazed by livestock, and greatly increased after removal of livestock. *2015-523 ASU, JF2013-94*

JUNCACEAE

Juncus balticus Willd. subsp. *ater* (Rydb.) Snogerup. Baltic Rush. Perennial; common; AQ. *JF2013-74*; *Wright 1818*; *Mauz 2004-119*

Juncus balticus Willd. subsp. *mexicanus* (Willd. ex Schult. & Schult. f.) Snogerup. Mexican Rush. Perennial; not found; AQ. *Tlucek 2009-05-26*; *White 2005-06-16*

Juncus bufonius L. Toad Rush. Winter annual; infrequent; AQ. *McManus 605*; *2017-792, 2016-689*

Juncus dudleyi Weigand. Dudley Rush. Perennial; not found; AQ. *Wright 1824*

Juncus torreyi Coville. Torrey Rush. Perennial; common; AQ. *Hazelton 125 ASU*; *JF2013-82, 2016-665, 2017-784 ASU*

IRIDACEAE

Sisyrinchium cernuum (E. P. Bicknell) Kearney. Nodding Blue-eyed Grass. Winter annual; not found; FP. Nearest population would be in Rincon Mountains. *Cowles 2007-03-26* (SEINet photo)

LILIACEAE

Calochortus kennedyi Porter. Desert Mariposa Lily. Root perennial; infrequent; AS. *2016-645*

POACEAE

Agrostis exarata Trin. Spike Bentgrass. Perennial; infrequent; CH. *2016-666*

Aristida adscensionis L. Six-Weeks Three-Awn. Summer annual; common; RX, DiAS, DiPT, FP. Most common annual *Aristida*. *White 2005-06-16 ASU, 2014-374*

Aristida purpurea Nutt. var. *parishii* (Hitchc.) Allred. Parish Threeawn. Perennial; occasional; FP. *Hazelton 108 ASU*; *White & Shorrock 2005-09-03 ASU*; also found in seedbank study of Stromberg et al. (2009)

Aristida ternipes Cav. Spider Grass. Perennial; infrequent; DiPT, FP. Found on rocky slopes and disturbed soils. *Shorrock 2005-09-03 ASU*; *2016-728*

**Arundo donax* L. Giant Reed. Perennial; infrequent; HT, CH. *Arundo* was planted near two different ranch buildings by the former owners of the Empirita Ranch, but David Scalero at Pima County Regional Flood Control District eradicated these. The current infestation is derived from private property outside the Preserve. *2015-528*

**Avena fatua* L. Wild Oat. Winter annual; infrequent; FP. Abundance might have decreased over time, perhaps due to fewer wet winters or fewer livestock incursions. *2015-509*

Bothriochloa barbinodis (Lag.) Herter. Cane Beard Grass. Perennial; infrequent; FP. *JF2013-214*

**Bothriochloa ischaemum* (L.) Keng. Yellow Bluestem. Perennial; rare; DiAS, FP. *JF2014-223*

Bouteloua aristidoides (Kunth) Griseb. Needle Grama. Summer annual; common; FP, DiPT. Found in dry and disturbed areas. *Hazelton 107 ASU*; *2014-371*

Bouteloua barbata Lag. var. *rothrockii* (Vasey) Gould. Rothrock Grama. Perennial; common; HT, DiPT, AS. Seems to favor disturbed soils in the Preserve. *JF2013-143, 2014-390, 2014-434*

Bouteloua curtipendula (Michx.) Torr. Side-Oats Grama. Perennial; occasional; DiAS, HT, PT. Found in open grassy areas and rocky outcrops. *2013-183*

Bouteloua eriopoda (Torr.) Torr. Black Grama. Perennial; common; RX, AS. *2015-456*

Bouteloua repens (Kunth) Scribn. & Merr. Slender Grama. Perennial; occasional; CH, HT, AS, RX. *JF2013-212, JF2013-150, 2015-595*

Bouteloua trifida Thurb. ex S. Watson. Red Grama. Perennial; occasional; AS. *2016-729 ASU*

Bromus carinatus Hook. & Arn. California Brome. Winter annual; occasional; FP. *2015-492, 2017-763 ASU*

**Bromus catharticus* Vahl var. *catharticus*. Rescue Grass. Winter annual; occasional; AS. *2013-58*

**Bromus diandrus* Roth. Ripgut Brome. Perennial; infrequent; FP. *Mauz 2005-45*; *2014-322*

Bromus marginatus Nees. ex Steud. Mountain Brome. Perennial; infrequent; FP. In shaded understory of mesquite forests. *2015-501*

**Bromus rubens* L. Red Brome. Winter annual; occasional; HT, WA, FP. Often forms carpets, especially in sandy soils. Abundance depends on winter rains. This species decreased greatly after removing livestock. *2017-779*

**Cenchrus ciliaris* L. Buffelgrass. Perennial; occasional; DiAS, CH, WA. Found in hot sunny locations. Has increased somewhat over time; abundant along I-10. *2013-184*

**Cenchrus setaceus* (Forssk.) Morrone. Crimson Fountaingrass. Perennial; rare; WA, RX. The source area for this is located in the Agua Verde drainage just upstream of the Preserve boundaries within Colossal Cave Park. This population should be eradicated. *2014-454*

Cenchrus spinifex Cav. Coastal Sandbur. Summer annual; rare; FP. *2015-549*, *Cowles 2005-09-16* (SEINet photo)

Chloris virgata Sw. Feather Fingergrass. Summer annual; occasional; FP. Found in floodplain grasslands, this species decreased after removal of livestock. *2014-388*

**Cortaderia* sp. Pampas Grass. Perennial; not found; CH. Removed by hand from a site that was not associated with any cultivation; I've not seen it since. I believe the single but mature plant established from windblown seed. *JF1995-09-24* (SEINet photo)

Cottea pappophoroides Kunth. Cotta Grass. Perennial; occasional; HT. *2014-451 ASU*

**Cynodon dactylon* (L.) Pers. Bermuda Grass.Bermudagrass. Perennial; abundant; CH, DiFP, FP, WA. Found in areas of trampling such as trails, and in areas where muddy water settles in the floodplain. "Giant" bermuda grass was also planted deliberately at the 60-acre clearing known as the Pantano Jungle site in the 1970s for livestock, according to the former caretakers of the pasture. *2016-672*

Dasyochloa pulchella (Kunth) Willd. ex Rydb. False Fluff Grass. Fluffgrass. Perennial; abundant; PT, HT, AS, RX, DiAS. Grows mainly on dry, alluvial slopes. *2018-884*

Digitaria californica (Benth.) Henrard. California Crab Grass.Arizona Cottontop. Perennial; infrequent; HT. Found in open areas, on fine-textured soils. *JF2013-210*

Diplachne fusca ssp.(L.) P. Beauv. ex Roem. & Schult. subsp. *uninervia* (J. Presl) P. M. Peterson & N. Snow. Bearded Beetle Grass. Mexican Sprangletop. Summer annual; infrequent; DiHT, FP. *2016-634*, *2016-716*

Disakisperma dubium (Kunth) P. M. Peterson & N. Snow. Red Sprangletop. Perennial; infrequent; FP. *2015-578 ASU*; *Mauz 2004-97 ASU*

**Echinochloa colona* (L.) Link. Jungle Rice. Summer annual; common; HT, DiHT, FP, CH. *2016-737*, *Mauz 2004-118*

**Echinochloa crus-galli* (L.) P. Beauv. Large Barnyard Grass. Perennial; infrequent; CH. *Mauz 2004-100.*

Elymus canadensis L. Nodding Wild Rye. Perennial; abundant; FP, WA. This is the common *Elymus* growing in partial shade of cottonwood forests and well-watered young mesquite bosques. Increased after removal of livestock. *2017-826*

Elymus elymoides (Raf.) Swezey. Squirreltail. Perennial; occasional; FP. *2017-764*

**Enneapogon cenchroides* (Licht. ex Roem. & Schult.) C. E. Hubb. South African Nine-Awn Pappusgrass. Annual; occasional; AS, DiAS. Found on disturbed sites. *2015-556*

Enneapogon desvauxii P. Beauv. Nine-Awn Pappusgrass. Perennial; occasional; DiAS. *2014-431*

**Eragrostis cilianensis* (All.) Vignolo ex Janch. Stink Grass. Annual; infrequent; FP, CH. Found especially in moist soil environments. *2014-424*

**Eragrostis curvula* (Schrad.) Nees. Weeping Lovegrass. Perennial; infrequent; WA. *2014-345*

**Eragrostis echinochloidea* Stapf. African Lovegrass. Perennial; infrequent; FP. Found in floodplain grasslands. *2015-594*

**Eragrostis lehmanniana* Nees. Lehmann Lovegrass. Perennial; abundant; DiAS, AS, PT, DiPT, FP, HT. One of the most prevalent grasses in the Preserve. *2013-171 ASU*

Eragrostis lutescens Scribn. Six-Weeks Lovegrass. Summer annual; not found; FP. *Shorrock 2005-09-03 ASU*

Eragrostis mexicana (Hornem.) Link. Mexican Lovegrass. Summer annual; infrequent; FP, DiHT. Found primarily in fine-grained soils. *Hazelton 109 ASU*; *2016-633*

Eragrostis pectinacea (Michx.) Nees ex Steud. Tufted Lovegrass. Summer annual; infrequent; CH. *2015-527*

**Eragrostis pilosa* (L.) P. Beauv. Indian Lovegrass. Summer annual; not found; FP. *Hazelton 141 ASU* and found in the seedbank study of Stromberg et al. 2009.

**Eragrostis superba* Peyr. Wilman Lovegrass. Perennial; rare; WA, DiHT. *2015-541*

Eriochloa acuminata (J. Presl) Kunth. Taper-Tip Cup Grass. Tapertip Cupgrass. Summer annual; not found; FP. *Hazelton 111 ASU*

Eriochloa aristata Vasey. Bearded Cup Grass. Cupgrass . Summer annual; common; FP. *2015-54*, *2014-354*

Heteropogon contortus (L.) P. Beauv. Twisted ex Roem. & Schult. Tanglehead. Perennial; occasional; WA, RX. Found especially on limy old basin fill deposits. *2014-455*

Hilaria jamesii (Torr.) Benth. James Galleta. Perennial; infrequent; AS. *2016-709*

Hilaria mutica (Buckley) Benth. Tobosa Grass. Perennial; occasional; RX, PT. Found on Pantano Formation especially. *2013-130*

Hopia obtusa (Kunth) Zuloaga & Morrone. Vine-Mesquite. Perennial; rare; HT. *2016-708*

Hordeum arizonicum Covas. Arizona Barley. Winter annual; infrequent; FP. *2013-64*

**Hordeum murinum* L. subsp. *leporinum* (Link) Arcang. Hare Barley. Winter annual; infrequent; FP. *2016-613*; *Cowles 2005-09-16* (SEINet photo)

Leptochloa crinita (Lag.) P. M. Peterson & N. Snow. Twoflower Trichloris. Perennial; common; CH, FP, HT. *JF2013-162*

Leptochloa panicea (Retz.) Ohwi subsp. *brachiata* (Steud.) N. Snow. Red Sprangletop. Summer annual; rare; HT. Found in moist, stable microhabitats, including cienegas elsewhere. *2018-888*

Leptochloa panicea (Retz.) Ohwi subsp. *mucronata* (Michx.) Nowack. Mucronate Sprangletop. Summer annual; infrequent; PT. *2017-809*

Leymus triticoides (Buckley) Pilg. Beardless Wild Rye. Perennial; not found; FP. Found near intermittent streamflow by *White 2005-06-15 ASU*

Muhlenbergia asperifolia (Nees & Meyen ex Trin.) Parodi. Alkali Muhly. Perennial; infrequent; WA. Seeds frequently infected with smut which produces a globose body with dark brown to black spores. *2013-20*

Muhlenbergia fragilis Swallen. Delicate Muhly. Summer annual; rare; RX. Found on rocky, limy slopes and cliffs and sandy slopes. *2017-806*

Muhlenbergia microsperma (DC.) Kunth. Little-Seed Muhly. Summer annual; infrequent; FP, HT. *2016-618*

Muhlenbergia porteri Scribn. ex Beal Bush Muhly. Perennial; common; PT, RX, HT. A bunchgrass of Pleistocene alluvial terrace slopes. *2013-155*

Muhlenbergia rigens (Benth.) Hitchc. Deer Grass. Perennial; common; CH, FP, WA. This species increased its cover initially after removal of livestock, then decreased under shade of trees. *2016-717*

**Panicum antidotale* Retz. Giant Panicgrass. Perennial; occasional; CH, FP, DiPT. Occasional. Deliberately planted in at least one location as a pasture grass, now spreading. *Mauz 2004-102*; *JF2013-54*

Panicum hallii Vasey. Hall Panicgrass. Perennial; common; FP, HT. *2014-423*

Panicum hirticaule J. Presl. Mexican Panicgrass. Summer annual; occasional; FP. Frequency increases during long wet summers. *2014-359*

Pappophorum vaginatum Buckley. Whiplash Pappus Grass. Perennial; common; DiHT, RX. Found in western Preserve. *2015-542*

**Paspalum dilatatum* Poir. Dallisgrass. Perennial; infrequent; CH. Found in moist soil environment. *2017-789*

Paspalum distichum L. Knotgrass. Perennial; infrequent; CH. Like *P. dilatatum*, found in moist soils. *Mauz 2004-98*

Phalaris caroliniana Walter. May Grass. Winter annual; infrequent; CH. Found near water, usually. *2013-65*

Poa bigelovii Vasey & Scribn. Bigelow Blue Grass. Winter annual; infrequent; HT, FP, CH. *Adams 105*

**Polypogon monspeliensis* (L.) Desf. Annual Rabbit's-Foot Grass. Winter annual; common; CH. Seems to tolerate drying of the stream channel a bit more than *P. viridis*. *2015-525*

**Polypogon viridis* (Gouan) Breistr. Beardless Rabbit's-Foot Grass. Perennial; occasional; CH. Found in wet soil environments, favoring shade of the cottonwoods. *Shorrock 2006-05-15 ASU*; *JF2013-63, 2016-666 ASU, 2017-785 ASU*

**Schismus arabicus* Nees. Arabian Mediterranean Grass. Winter annual; infrequent; HT, CH. *Hazelton 116 ASU*

**Schismus barbatus* (Loefl. ex L.) Thell. Common Mediterranean Grass. Winter annual; not found; FP. *Hazelton 171 ASU*

Scleropogon brevifolius Phil. Burro Grass.Burrograss. Perennial; infrequent; HT. *2018-903*

Setaria grisebachii E. Fourn. Grisebach Bristlegrass. Summer annual; occasional; FP. *2016-*

717

Setaria leucopila (Scribn. & Merr.) K. Schum. Streambed Bristlegrass. Perennial; common; FP, HT. This is the most common *Setaria* of the floodplain and terrace. *JF2013-56*

Setaria macrostachya Kunth. Plains Bristlegrass. Perennial; common; AS. *2014-426*

**Sorghum halepense* (L.) Pers. Johnsongrass. Perennial; abundant; CH, FP. A dominant plant cover in ephemeral stream floodplains where the sediment regime is primarily depositional, but also common in moist channel settings. This species has increased, but the increase did not seem to coincide with removal of livestock. *2016-667*

Sphenopholis obtusata (Michx.) Scribn. Prairie Wedgescale. Perennial; not found; CH. *Wright 1823 NHI*

Sporobolus airoides (Torr.) Torr. Alkali Sacaton. Perennial; occasional; DiMT, WA, FP, HT. *2013-165*; *Mauz 2004-87*

Sporobolus contractus Hitchc. Spike Dropseed. Perennial; infrequent; WA, FP. *2017-817*

Sporobolus cryptandrus (Torr.) A. Gray. Sand Dropseed. Perennial; occasional; CH, FP. *2014-319*

Sporobolus wrightii Munro ex Scribn. Big Sacaton. Perennial; HT, WA. Occasional. Found in riverbanks, sandy washes, and floodplains. This species recruited naturally at the alluvial fans created by certain tributary confluences. Some plants on terraces appear to be relictual. With help from Arizona Native Plant Society, and caretakers Neal and Diane Hanna, we planted 670 seedlings propagated from seed collected in the Preserve. (The area had been cleared by rootplowing in 1974 to plant alfalfa and then Bermuda grass.) Initial mortality of the seedlings was quite low, but over the years of drought, progressively more individuals were lost. Still, some plants have matured into robust individuals. *J. R. Reeder 7301*

Tridens muticus (Torr.) Nash. Slim tridens. Perennial; common; AS, RX. Grows in some of the driest soils of alluvial slopes and bedrock outcrops. *2014-225*

**Triticum aestivum* L. Wheat. Annual; rare; CH. Cultivated wheat, probably escaped from upstream seeding along I-10, but has not persisted. *2016-663 ASU*

Urochloa arizonica (Scribn. & Merr.) Morrone & Zuloaga. Arizona Signalgrass. Summer annual; occasional; CH. *2017-794*

Vulpia octoflora (Walter) Rydb. Eight-Flower Six-WeeksFescue. Winter annual; occasional; WA, FP, CH, RX. *Hazelton 114 ASU*, *2019-929* (SEINet photo)

Zuloagaea bulbosa (Kunth) E. Bess. Bulb Panicgrass. Perennial; rare; DiHT. *2015-583*

POTAMOGETONACEAE

Zannichellia palustris L. Horned Pondweed. Perennial; occasional; AQ. Found in still ponds. *2017-753*

TYPHACEAE

Typha domingensis Pers. Narrow-leafed Cattail. Root perennial; common; CH, AQ. Forms dense stands where the water is available, usually co-occurring with *Schoenoplectus*. G*JF2013-85*; *Tluczek 2009-05-27 ASU*

Typha latifolia L. Broad-leafed Cattail. Root perennial; rare; CH, AQ. This cattail species came in on the heels of a flood. Will it persist? *Ian Murray 963*

Flora and Vegetation of Rock Horned Lizard (*Phrynosoma ditmarsi*) Sites, Rancho Las Playitas, Sonora, Mexico

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Abstract: The flora and vegetation were inventoried at six Rock Horned Lizard (*Phrynosoma ditmarsi*) sites on Rancho las Playitas near Bacoachi, Sonora, Mexico. A total of 137 plant species in 38 families was documented. Species richness was highest in Poaceae (22 species), Asteraceae (21 species), Fabaceae (15 species), Malvaceae (9 species), Euphorbiaceae (8 species), and Cactaceae (6 species). Rancho Las Playitas is in the transition zone between foothills thornscrub (tropical) and desert grassland (temperate). Rock Horned Lizard habitat is in foothills thornscrub on rocky slopes.

Figure 1. Male Rock Horned Lizard from Rancho Las Playitas near Bacoachi in breeding color in October 2021. Photo by Stephen F. Hale.

Flora and Vegetation of Rock Horned Lizard (*Phrynosoma ditmarsi*) Sites, Rancho Las Playitas, Sonora, Mexico.
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FLORA AND VEGETATION OF ROCK HORNED LIZARD (*PHRYNOSOMA DITMARSI*) SITES

INTRODUCTION

On the 1890-91 Carl Lumholtz Expedition to Mexico, a lizard with a flat body was collected with a locality recorded as "Sonora." On the 1897 expedition, two more individuals were collected "a short distance over the border of Arizona, in old Mexico, state of Sonora". In 1906, the Norwegian-born American herpetologist Leonhard Stejneger described the new lizard as *Phrynosoma ditmarsi* in honor of Raymond L. Ditmars, herpetologist at the New York Zoological Society (later the Bronx Zoo; Stejneger 1906; Figure 1). This animal, now known as the Rock Horned Lizard, was not found again for 73 years (Lowe et al. 1971). Even after 1972, it was known from only a few localities in Sonora. Since 2009, *P. ditmarsi* have been found in quite a few areas on Sky Island Alliance's Madrean Archipelago Biodiversity Assessment and Greater Good Charities' Madrean Discovery Expeditions (MDE) biotic inventory programs. It is now known from over 30 localities in Sonora (Turner et al. 2017, Aguilar-M. and Van Devender 2018). Here we present the local flora and characterize vegetation structure at six Rock Horned Lizard localities on Rancho Las Playitas west-southwest of Bacoachi, Sonora.

Figure 2. Picacho de Bacoachi. Photo by Ana L. Reina-Guerrero.

STUDY AREA

The MDE Expedition Rancho Las Playitas on September 27 to October 5, 2021, focused on studying the ecology of *P. ditmarsi.* The area is near the Picacho de Bacoachi (Figure 2) between the Ríos Sonora and Bacanuchi, 50 km south-southeast of Cananea and 86

km south of the Arizona border. The border between the municipalities of Arizpe and Bacoachi passes through the study area.

Three localities (Pd#1, Pd#3, and Pd#5) were close to Cerro Basaitequi at 1250-1300 m elev. Three localities (Pd#7, Pd#8, and Pd#11) were in the Arroyo Las Padercitas area at 1150-1210 m elev. Detailed plant lists were compiled on October 1-3, 2021. The coordinates are not presented here to protect *Phrynosoma ditmarsi*. There are 2593 observations in 430 taxa in the MDE database (madreandiscovery.org) in a 10 km search radius of a central point (30.57°N 110.12°W) in the six *P. ditmarsi* sites. Many of the records also have photo vouchers. Voucher specimens of most taxa were deposited in the herbaria of the University of Arizona (ARIZ) and the Universidad de Sonora (USON).

Figure 3. Basaitequi plants. A. *Lysiloma watsonii* (*tepeguaje*). Photo by A. L. Reina-G. B. *Capsicum annuum* (*chiltepín*). Photo by S. F. Hale. C. *Forestiera angustifolia* (desert olive). Photo by R. Wayne Van Devender. D. *Dryopetalon runcinatum* (rock mustard). Photo by S. F. Hale.

FLORA

A total of 137 plant species in 38 families were observed at the *P. ditmarsi* sites (Appendix 1). The families with the most species were Poaceae (22 species), Asteraceae (21 species), Fabaceae (15 species), Malvaceae (9 species), Euphorbiaceae (8 species), and Cactaceae (6 species). The life forms of the flora are trees (8), shrubs (20), woody vines (2), a

woody parasite, subshrubs (19), rosette succulents (4), stem succulents (6), herbaceous perennials (20), annuals (35), perennial grasses (13), and annual grasses (9). Only four grasses (*Cynodon dactylon, Eragrostis cilianensis*, *Pennisetum ciliare*, and *Melinis repens*) were non-native species (2.9%), and of these, only the South American annual grass *E. cilianensis* was common. Although *P. ciliare* (buffelgrass) is a very serious invasive species in many areas in Sonora, only a few plants were seen. However, this subshrub grass has the potential to expand rapidly, burns often, and is a potential threat to the *P. ditmarsi* habitat. Woody plants were 36.5% of the flora, herbs were 56.2%, and succulents were 7.3%. Plants large enough to be structural dominants (trees, shrubs, and larger succulents) in the vegetation were 25.5%.

The flora and vegetation structure were very similar at the six *Phrynosoma ditmarsi* sites. There are 14-32 species of woody plants at the six *P. ditmarsi* sites (11-17 trees and shrubs, 2-14 subshrubs). The shrubs *Fouquieria splendens, Lysiloma watsonii* (Figure 3A), and *Prosopis velutina,* the woody vine *Nissolia schottii,* and the perennial grasses *Bouteloua curtipendula* and *B. diversispicula* were found at all six sites. The shrubs *Celtis pallida, Eysenhardtia orthocarpa, Fraxinus gooddingii,* and *Jatropha cardiophylla*, the stem succulent *Yucca madrensis,* and the perennial grasses *B. repens* and *Bothriochloa barbinodis* were observed at five sites. The shrubs and subshrubs *Abutilon abutiloides, Acalypha papillosa, Brickellia coulteri, Bursera fagaroides, Calliandra eriophylla, Dodonaea viscosa, Juniperus arizonica, Krameria erecta,* and *Mimosa dysocarpa*, the stem succulent *Cylindropuntia thurberi,* and the perennial grass *Heteropogon contortus* were seen at four sites. Site Pd#1 had more cover of the perennial grass *Bouteloua repens*, while site Pd#7 had a patch of *Agave schottii*.

Figure 4. Lush FTS vegetation in early October 2021 after generous summer monsoon rains on Cerro Basaitequi and ridge to the west. Picacho de Bacoachi is in the background. Photo by Charles Hedgcock.

Abutilon abutiloides, Acalypha papillosa, Bursera fagaroides, Celtis pallida, Condalia correllii, Cylindropuntia thurberi, Eysenhardtia orthocarpa, Lysiloma watsonii, and *Prosopis velutina* are typical FTS plants. Other FTS plants less common at the sites include *Capsicum annuum* (Figure 3B), *Commicarpus scandens, Erythrina flabelliformis, Lagascea decipiens, Randia sonorensis, Sarcomphalus obtusifolius,* and *Yucca madrensis.* Grassland species on the rocky slopes include *Calliandra eriophylla, Dalea pulchra, Dasylirion wheeleri, Juniperus arizonica*, *Mimosa dysocarpa,* and *Salvia parryi. Quercus oblongifolia* is an oak woodland species at the lower end of its elevational range. *Forestiera angustifolia* (Figure 3C) and *Fraxinus gooddingii* are shrubs that are more common in northeastern Sonora and southeastern Arizona.

VEGETATION

Much of the Chihuahuan Desert from Chihuahua and western Texas west to southeastern Arizona and northeastern Sonora is a mosaic of desertscrub on rocky limestone slopes and desert grassland on deep soils in the adjacent valleys (Van Devender et al. 2013). The transition from foothills thornscrub (FTS) to desert grassland on Rancho Las Playitas is similar with rocky slopes dominated by shrubs and flatter areas by grasses. *Phrynosoma ditmarsi* lives on rocky slopes where the vegetation is more FTS (Figs 4 and 5). Plants large enough to provide shelter for *P. ditmarsi* among the rocks are *Lysiloma watsonii, Mimosa dysocarpa,* and *Prosopis velutina,* as well as *Celtis pallida, Cylindropuntia thurberi, Forestiera angustifolia, Fouquieria splendens, Fraxinus gooddingii,* and *Mariosousa millefolia. Lysiloma watsonii* is a tree in tropical deciduous forest in southern Sonora but grows as a shrub in FTS further north. *Lysiloma watsonii* reaches its northern distribution close to the Arizona border near Nogales, except for a disjunct population in the Rincon Mountains near Tucson, Arizona. In some areas in Sonora, it forms a distinct transitional vegetation between FTS and oak woodland. At Basaitequi, *L. watsonii* is transitional between FTS and desert grassland.

Figure 5. *Phrynosoma ditmarsi* FTS habitat at Basaitequi. Photo by Stephen L. Minter.

The vegetation in lower areas in Basaitequi below the *Phrynosoma ditmarsi* habitat is relatively open desert grassland with fewer shrubs. Dominant perennial grasses are *Bouteloua chondrosioides, B. curtipendula, B. repens,* and *Bothriochloa barbinodis.* Shrubs in lowland habitats are *Aloysia gratissima, Baccharis sarothroides, B. thesioides,* and *Gymnosperma glutinosum.*

In the summer monsoon rainy season from July to September into October and November in fall, dense herbs and grasses between the shrubs provide cover and shade on the rocky slopes. Especially common are annual herbs and vines (*Amaranthus palmeri, Eriogonum abertianum,* and *Ipomoea costellata*), perennial grasses (*Bouteloua curtipendula, B. repens*, and *Heteropogon contortus*), and annual grasses (*B. aristidoides, B. barbata, Eragrostis cilianensis*, and *Panicum alatum*). The last flowers were seen in December on *Gymnosperma glutinosum, Plumbago zeylanica,* and *Viguiera dentata*. In February after a few modest rains, there were new leaves on *Ambrosia confertiflora, Bouteloua repens*, and some *Fouquieria splendens,* and flowers on *Dalea pulchra* and *Sida abutilifolia*. The spring annuals *Descurainia pinnata, Drypetalon runcinatum* (Figure 3D), and *Phacelia distans* were growing in shady areas.

A diverse insect fauna feeds on the plants from late summer into October and November. These insects are a rich food source for *Phrynosoma ditmarsi* during the fall breeding season, especially the diverse species of grasshoppers. Gradually the abundance of grasshoppers and butterflies declined in December. Later only a few small young grasshoppers and adult butterflies were still present. The activity patterns of *P. ditmarsi* tracked the insect fauna.

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APPENDIX 1. Plants at Rock Horned Lizard sites. * = non-native. PV = photo voucher in MDE database record, each observation is listed by its Catalog Number, e.g., MDE-53227.

Acanthaceae

Elytraria imbricata (Vahl) Pers. (PV: MDE-53227; *Van Devender 2021-437*, USON)
Ruellia ciliatiflora Hook. (*Hale 6508,* ARIZ)
Tetramerium nervosum Nees (PV: MDE-53462; *Van Devender 2021-405*, USON)

Amaranthaceae

Amaranthus palmeri S. Watson (*Reina-G. 2022-251,* USON)
Chenopodium neomexicanum Standl. (*Reina-G. 2022-127*, USON)
Gomphrena sonorae Torr. (PV: MDE-53278; *Van Devender 2021-442*, USON)
Guilleminea densa (Willd.) Moc. (*Van Devender 2021-372*, USON)

Apocynaceae

Mandevilla brachysiphon (Torr.) Pichón (PV:MDE-54693; *Reina-G. 244,* ARIZ, USON)

Aristolochiaceae

Aristolochia watsonii Wooton & Standl. (PV: MDE-53105; *Van Devender 2022-172*, ARIZ)

Asparagaceae

Agave schottii Engelm. (PV: MDE-55812; *Van Devender 2022-174*, ARIZ, USON)
Dasylirion wheeleri S. Watson ex Rothr. (PV: MDE-53211; *Van Devender 2022-195,* ARIZ, USON)
Nolina microcarpa S. Watson (PV: MDE-54878; *Van Devender 2022-192,* ARIZ, USON)
Yucca madrensis Gentry (PV: MDE-53484; *Reina-G. 2022-90*, ARIZ, USON)

Asteraceae

Acourtia thurberi (A. Gray) Reveal & R.M. King (*Van Devender 2021-420*, USON)
Adenophyllum porophyllum (Cav.) Hemsl. (*Van Devender 2021-439*, ARIZ, USON)
Ambrosia confertiflora DC. (PV: MDE-53089)
Artemisia ludoviciana Nutt. (*Van Devender 2021-412*, USON)
Baccharis thesioides Kunth (*Van Devender 2021-448*, ARIZ, USON)
Brickellia coulteri A. Gray (*Reina-G. 2022-84*, ARIZ, USON)
Encelia farinosa A. Gray (*Reina-G. 2022-98*, ARIZ, USON)
Gymnosperma glutinosum (Spreng.) Less. (PV: MDE-53284; *Van Devender 2021-367*, ARIZ, USON)
Lagascea decipiens Hemsl. (*Van Devender 2021-497*, ARIZ)
Machaeranthera tagetina Greene (PV: MDE-;53327 *Van Devender 2021-424*, USON)
Melampodium appendiculatum B.L. Rob. (*Van Devender 2021-425*, USON)
Pectis prostrata Cav. (PV: MDE-53388; *Van Devender 2021-443*, ARIZ)
Porophyllum gracile Benth. (*Reina-G. 2022-81*, ARIZ)
Porophyllum macrocephalum DC. (PV: MDE-53400; *Van Devender 2019-629,* USON)
Senecio flaccidus Less. (PV: MDE-54751; *Hale 6547*, ARIZ)
Tithonia thurberi A. Gray (*Van Devender 2021-411*, USON)
Trixis californica Kellogg (*Van Devender 2021-378*, ARIZ, USON)
Viguiera dentata (Cav.) Spreng (PV: MDE-53477; *Van Devender 2021-421,* USON)

Xanthisma gracile (Nutt.) D.R. Morgan & R.L. Hartm. (*Reina-G.-670.* USON)
Zinnia peruviana (L.) L. (Reina-G. 2021-471: USON)
Zinnia zinnioides (Kunth) Olorode & A.M. Torres (PV: MDE-53489; *Reina-G.2021-421*, USON)

Boraginaceae

Phacelia distans Benth. (PV: MDE-54305; *Reina-G. 2022-94*, ARIZ, USON)

Brassicaceae

Descurainia pinnata (Walter) Britton (*Reina-G. 2022-07*, DES)
Dryopetalon runcinatum A. Gray (*Reina-G. 2022-08*, ARIZ, USON)

Burseraceae

Bursera fagaroides (Kunth) Engl. var. *elongata* McVaugh & Rzed. (PV: MDE-53159; *Van Devender 2021-381,* ARIZ, USON)

Cactaceae

Cylindropuntia thurberi (Engelm.) F.M. Knuth (PV: MDE-53199; *Van Devender 2022-188*, ARIZ, CDIIR, MEXU)
Mammillaria grahamii Engelm. ssp. *grahamii* (PV: MDE-53334; *Reina-G. 2021-511*, ARIZ, CDIIR, MEXU)
Opuntia chlorotica Engelm. & Bigel. (PV: MDE-55519; *Reina-G. 2022-184*, ARIZ, CDIIR, MEXU)
Opuntia aff. *durangensis* Britton & Rose (PV: MDE-53379; *Van Devender 2021-515*, ARIZ, CDIIR, MEXU)
Opuntia aff. *wilcoxii* Britton & Rose (PV: MDE-53380; Van Devender 2022-186: ARIZ, CDIIR, MEXU)
Stenocereus thurberi (Engelm.) F. Buxb. (PV: MDE-53454; *Reina-G. 2021-512*, ARIZ, CDIIR, MEXU)

Cannabaceae

Celtis pallida Torr. (PV: MDE-53169; *Van Devender 2022-168*, USON)
Celtis reticulata Torr. (PV: MDE-53172; *Van Devender 2022-169*, USON)

Convolvulaceae

Evolvulus alsinoides L. var. *angustifolia* Torr. (PV: MDE-52355; *Van Devender 2021-392*, USON)
Ipomoea costellata Torr. (*Hale 6494,* ARIZ)
Ipomoea cristulata Hallier f. (PV: MDE-53299: *Reina-G. 20-22-373,* ARIZ)
Ipomoea ternifolia Cav. var. *leptotoma* (Torr.) J.A. McDonald (PV: MDE-53301; *Reina-G. 2022-354*)

Cupressaceae

Juniperus arizonica (R.P. Adams) R.P. Adams (PV: MDE-53308; *Reina-G. 2022-137*, ARIZ)

Euphorbiaceae

Acalypha neomexicana Müll. Arg. (*Van Devender 2021-435,* USON)
Acalypha ostryifolia Riddell (*Van Devender 2021-414*, ARIZ)
Acalypha papillosa Rose (*Carnahan 3841*, ARIZ)
Euphorbia heterophylla L. (*Van Devender 2021-388*, USON)
Euphorbia hirta L. (PV: MDE-53249; *Van Devender 2021-494*, ARIZ)
Euphorbia hyssopifolia L. (*Van Devender 2021-387*, USON)

Jatropha cardiophylla (Torr.) Müll. Arg. (PV: MDE-53303; *Van Devender 2022-205*, USON)
Tragia nepetifolia Cav. var. *dissecta* Müll. Arg. (*Van Devender 2021-382*, ARIZ)

Fabaceae

Calliandra eriophylla Benth. (PV: MDE-53162; *Reina-G. 2022-128*, USON)
Chamaecrista nictitans (L.) Moench (*Van Devender 2021-409*, USON)
Crotalaria pumila (Rose) Lavin (PV: MDE-53190; *Van Devender 2021-413*, USON)
Dalea pringlei A. Gray (*Van Devender 2021-417*, USON)
Dalea pulchra Gentry (PV: MDE-53209; *Reina-G. 2022-04*, ARIZ)
Desmanthus bicornutus S. Watson (PV: MDE-53214; *Van Devender 2021-375*, USON)
Erythrina flabelliformis Kearney (PV: MDE-53245; *Van Devender 2022-173*, ARIZ, USON)
Eysenhardtia orthocarpa (A. Gray) S. Watson (PV: MDE-53258; *Van Devender 2022-164,* ARIZ, USON)
Lysiloma watsonii Rose (PV: MDE-53322; *Reina-G. 2022-131*, ARIZ)
Mariosousa millefolia (S. Watson) Seigler & Ebinger (*Hale 6524,* ARIZ)
Mimosa dysocarpa Benth. ex A. Gray (PV: MDE-53352; *Hale 6531,* ARIZ)
Nissolia schottii (Torr.) A. Gray (PV: MDE-53370; *Van Devender 2021-418*, USON)
Prosopis velutina Wooton (*Reina-G. 2022-105*, ARIZ, USON)
Senegalia occidentalis (Rose) Britton & Rose (PV: MDE-55913)
Vachellia farnesiana (L.) Wight & Arn. (*Van Devender 2022-171,* ARIZ, USON)

Fagaceae

Quercus oblongifolia Torr. (PV: MDE-53419; *Reina-G. 2022-350,* USON)

Fouquieriaceae

Fouquieria splendens Engelm. (PV: MDE-53267; *Reina-G. 2022-97*, USON)

Krameriaceae

Krameria erecta Willd. ex Schult. (*Van Devender 2021-430*, USON)

Lamiaceae

Salvia parryi A. Gray (*Reina-G. 2022-78*, ARIZ, USON)
Salvia subincisa Benth. (*Hale 6522,* ARIZ)

Loasaceae

Mentzelia albicaulis (Douglas) Douglas ex Torr. & A. Gray (*Reina-G. 2022-358*, USON)

Malpighiaceae

Cottsia californica (Benth.) W.R. Anderson & C. Davis (*Reina-G. 2022-248,* ARIZ)

Malvaceae

Abutilon abutiloides (Jacq.) Garcke ex Britton & Wilson (PV: MDE-54742; *Van Devender 2021-383*, USON)
Abutilon incanum (Link) Sweet (*Van Devender 2021-377*, USON)
Anoda cristata (L.) Schltdl. (PV: MDE-29470; *Van Devender 2021-431*, USON)
Ayenia filiformis S. Watson (*Van Devender 2021-428,* USON)
Corchorus hirtus L. (*Van Devender 2021-487*, ARIZ)
Gossypium thurberi Todaro (*Van Devender 2021-366A*, USON)
Hibiscus aciularis Standl. (PV: MDE-54536; *Reina-G. 2022-75*, ARIZ)
Malvastrum bicuspidatum (S. Watson) Rose (*Van Devender 2021-374*, USON)

Waltheria indica L. (*Van Devender 2021-373*, ARIZ, USON

Martyniaceae

Proboscidea parviflora (Wooton) Wooton & Standl. (PV: MDE 53407; *Reina-G. 2022-309,* ARIZ)

Montiaceae

Phemeranthus aurantiacus (Engelm.) Kiger (*Reina-G. 2022-248,* ARIZ, USON)

Nyctaginaceae

Boerhavia coccinea Mill (*Reina-G. 2022-250,* USON)

Boerhavia erecta L. (*Van Devender 2021-408*, USON)

Commicarpus scandens (L.) Standl. (*Hale 6557,* ARIZ)

Oleaceae

Forestiera angustifolia Torr. (PV: MDE-53264; *Van Devender 2021-455*, ARIZ)

Fraxinus gooddingii Little (PV: MDE-53273; *Van Devender 2022-166*, USON)

Petiveriaceae

Rivina humilis L. (*Van Devender 2021-451*, USON)

Plumbaginaceae

Plumbago zeylanica L. (PV: MDE-55719; *Van Devender 2022-155*, ARIZ)

Poaceae

Aristida adscensionis L. (*Van Devender 2021-396*, USON)

Aristida ternipes Cav. var. *ternipes (Van Devender 2021-432*, ARIZ)

Bothriochloa barbinodis (Lag.) Herter (*Van Devender 2021-394*, ARIZ)

Bouteloua aristidoides (Kunth) Griseb. (*Van Devender 2019-688,* ARIZ, USON)

Bouteloua barbata Lag. var. *barbata* (*Van Devender 2021-434*, ARIZ)

Bouteloua chondrosioides (Kunth) Benth. ex S. Watson (*Van Devender 2021-423*, ARIZ)

Bouteloua curtipendula (Michx.) Torr. (*Van Devender 2019-635,* USON)

Bouteloua diversispicula Columbus (*Van Devender 2021-440*, ARIZ)

Bouteloua repens (Kunth) Scribn. & Merr. (*Van Devender 2021-386*, ARIZ, MEXU, USON)

Chloris virgata Sw. (*Van Devender 2021-401*, ARIZ)

**Cynodon dactylon* (l.) Pers. (Van Devender 2022-159; ARIZ, USON)

Dinebra panicea (Retz.) P.M. Peterson & N. Snow subsp. *brachiata* (Steud.) P.M. Peterson & N. Snow (*Van Devender 2021-428*, USON)

Disakisperma dubium (Kunth) P.M. Peterson & N. Snow (*Van Devender 2021-389*, ARIZ)

Enneapogon desvauxii P. Beauv. (*Van Devender 2021-447*, ARIZ)

**Eragrostis cilianensis* (All.) Link ex Vignolo (*Van Devender 2021-436*, ARIZ)

Heteropogon contortus (Elliott) Benth. (*Van Devender 2021-376*, ARIZ, USON)

**Melinis repens* (Willd.) Zizka (PV: MDE-53348; *Van Devender 2021-390*, USON)

Muhlenbergia microsperma (DC.) Kunth (*Van Devender 2021-427*, USON)

Panicum alatum Zuloaga & Morrone (*Van Devender 2021-398*, ARIZ)

**Pennisetum ciliare* (L.) Link (PV: MDE-53390; *Hale 6538,* ARIZ)

Setaria grisebachiii E. Fourn. (*Reina-G. 2021-460*, ARIZ)

Setaria macrostachya Kunth (*Van Devender 2021-369*, ARIZ, USON)

Polygonaceae

Eriogonum abertianum Torr. (PV; *Van Devender 2021-433*, USON)

Portulacaceae

Portulaca oleracea L. (*Reina-G. 2922-355,* USON)

Pteridaceae

Myriopteris lindheimeri (Hook.) J. Sm. (PV: MDE-54340: MDE-54340; *Van Devender 2022-306*, ARIZ)

Rhamnaceae

Adolphia infesta (Kunth) Meisn. (*Carnahan 3838*, ARIZ)

Condalia correllii M.C. Johnst. (*Reina-G. 2022-112*, ARIZ, USON)

Sarcomphalus obtusifolius (Hook. ex Torr. & A. Gray) Hauenschild (*Van Devender 2022-204*. ARIZ, USON)

Rubiaceae

Mitracarpus hirtus (L.) DC. (*Van Devender 2021-404*, USON)

Randia sonorensis Wiggins (PV: MDE-53422; *Van Devender 2021-444*, ARIZ)

Santalaceae

Phoradendron californicum Nutt. (*Van Devender 2021-507*, USON)

Sapindaceae

Dodonaea viscosa Jacq. var. *angustifolia* (L.f.) Benth. (*Reina-G. 2022-132*, USON)

Selaginellaceae

Selaginella rupincola Underw. (PV: MDE-55810; *Van Devender 2022-198*, TEX, USON)

Solanaceae

Capsicum annuum L. var. *glabriusculum* (Dunal) Heiser & Pickering (PV: MDE-53165; *Van Devender 2021-422*, ARIZ)

Solanum lumholtzianum Bartlett (PV: MDE-53447; *Van Devender 2021-384*, USON)

Verbenaceae

Aloysia gratissima (Gillies & Hook.) Tronc. (*Reina-G. 2022-93*, USON)

Bouchea dissecta S. Watson (PV: MDE-53130; *Reina-G. 2021-472*, TEX)

Zygophyllaceae

Kallstroemia grandiflora Torr. ex A. Gray (PV: MDE-53313; *Reina-G. 2022-240*, USON)

AGAVACEAE Part Two: *Hesperoyucca* (Engelm.) Baker

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Hesperoyucca (Engelm.) Baker **Our Lord's Candle, Lechuguilla, Quixote**

Plants perennial, with long-lived fibrous leaves arranged in basal rosettes, monocarpic with rosettes solitary, or plants polycarpic with multiple rosettes, forming small to large colonies via offsets, the individual rosettes dying after flowering, erect, acaulescent, scapose. LEAVES sessile, linear, rarely narrowly lanceolate, glaucous, blue-gray or green, rigid at maturity; margins mostly denticulate, corneous, pale yellow, the apex spinose. SCAPE tall, extending well beyond leaves, bracteate. INFLORESCENCES terminal congested panicles, bracteate, glabrous; rachis and peduncle reddish purple; bracts usually reflexed, deltoid. FLOWERS bisexual; perianth campanulate or globose; tepals six, distinct most of length, white or cream-white to greenish or purple-tinged, broadly lanceolate; stamens 6, the filaments thick, white to cream-white, papillose, the anthers terminal, reniform, yellow, with tufted pubescence, the pollen within a glutinous matrix; ovary superior, 3-loculed, placentation axile; style white; stigmas green, capitate, fringed with transparent, sticky papillae. FRUITS erect, capsular, narrowly to broadly obovoid (to ovate) or oblong-cylindric, symmetrical or constricted, loculicidal, puberulent, the epidermis somewhat resinous, smooth to verrucose. SEEDS many per locule, dull black, obovate, thin, flattened, tightly packed vertically. $n = 30$ (5 large, 25 small). — 3 species.; sw U.S., Baja C., Baja C. Sur and n Son., Mex.

Hesperoyucca newberryi (McKelvey) Clary (for John Newberry, American physician, naturalist, explorer, first geologist to visit Grand Canyon and first person to document the species with an herbarium specimen). —Plants monocarpic, the plant dying upon flowering, the rosettes single. LEAVES 37–60 cm long, 0.75–2.5 cm wide at base, rhombus-shaped in cross section, gray-green. SCAPE 1.25–3 m long, 6-10 cm diam. at ca 1.4 m from base of plant. INFLORESCENCES 1, 1.4–1.6 m high, 0.4–0.55 m at widest point, the inflorescence ½–3/4 length of scape, the lateral branches ascending in flower, often becoming pendulous in fruit. FLOWERS 34–70 mm long, 26–36 mm wide when fresh, the tepals cream, often with slight lavender purple flush distally, fused basally 3.5–5 mm, the outer tepals 30–63 mm long, 14–24 mm wide, the inner tepals 33–57 mm long, 15–26 mm wide; filaments 6-10.5 long, 2.4–4 mm wide, basally fused with tepals 4–6 mm, cream-white; ovary 10-14 mm long, 7–11.5 mm wide, white; style 1-2.1 mm long; stigma 2–5 mm high. FRUITS (20–)29–44 mm long, (14–)22–41 mm wide, ovoid to ovoid-cylindric, symmetrical or somewhat constricted near middle, smooth to roughly verrucose, the locule 20–38 mm long, 9–17 mm wide, greenish-tan to light brown, becoming dark brown with maturity, the placental wings inconspicuous to moderately formed. SEEDS 6–9.0 mm long, 5–8.0 mm wide. [*Yucca newberryi*

Vascular Plants of Arizona: Agavaceae Part two: ***Hesperoyucca*** (Engelm.) Baker. CANOTIA 18:182–188. 2022.

McKelvey].— Desert, rocky granite, limestone and basalt slopes from western Grand Canyon to Grand Wash Cliffs, Coconino and Mohave cos.; 400–1425 m (1310–4675 ft); Feb.-Apr.; n Son., Mex.

In Arizona, *Hesperoyucca newberryi* plants are distributed only in the Grand Canyon, from near Fern Glen Canyon at about Colorado River mile 168 (km 270), downriver to Grand Wash Cliffs at Colorado River mile 276 (km 444; miles measured from Lees Ferry), a distance of 108 miles (174 km); Southwest Environmental Network 2022). Although *H. newberryi* plants were reported to be restricted to the southern bank of the Colorado River and to below the rim of the Canyon (McKelvey 1947; Kearney and Peebles 1960), plants occur on both sides of the river and on the rims. However, populations appear to be two to three times greater in number on N, NE and NW-facing slopes (Hodgson, pers. obs.).

A disjunct population from the Arizona plants occurs ca. 275 miles to the south in Sonora, Mexico, near the Arizona-Mexico border in the Sierra del Viejo (Sierra Los Alacranes) on north-facing granitic rocky slopes (*Felger 85-719*, ASU). These plants were previously refered to as *Hesperoyuccca whipplei* (Torr.) Baker (Felger 2000; Clary 2001). However, recent fieldwork, collections (*Hodgson et al. 32502, 32503, 32504*, DES) and molecular data (Salywon, unpublished data) clearly place the Sonoran plants in *H. newberryi* (see Clary 2001 for key to the species). This disjunct distribution may be a result of Pleistocene interglacial episodes that fragmented and reduced populations that were formerly widespread in the Sonoran Desert (Van Devender 1990; see Segraves and Pellmyr 2001). Surviving populations occur mainly in Grand Canyon, which served as a Pleistocene refugia.

Pre-contact peoples may also have affected *H. newberryi* populations. *Hesperoyucca* sp. is documented from the Tinajas Altas, where the plants previously occurred at least 11,000 – 18,700 years ago based on leaf fragments in packrat middens (Van Devender 1990; Felger 2007; Felger et al. 2012). The tinajas in the Tinajas Altas provided water resources to not only bighorn sheep but people, the latter arriving here during the Paleo-indian Period that extends from 11,000 BCE or earlier to 8000 BCE (Felger et al. 2012). The nearby extant Sonoran plants may represent a relictual population that survived exploitation for food by bighorn sheep and possibly people whose habitation in the Sierra del Viejo (Sierra Los Alacranes) was discouraged because of the area's extreme aridity and lack of fresh water sources (Felger 2007; Felger et al. 2012).

Several indigenous groups used *Hesperoyucca whipplei* for food (stem, flower stalk, flowers, seeds), fiber (leaves) and soap (roots) (Parish 1891, cited in McKelvey 1947; Dodge 1897; Weiss 1994; Miegs 1939; Zigmond 1981; Hodgson 2001; Hope-King 2006; Wilken-Robertson 2017; Anderson and Keeley 2018). There is little, if any, documentation on *H. newberryi* uses. Hope-King (2006) cites use of *Hesperoyucca* by Yavapai, Zuni, Navajo and Hopi tribes; however, this is misleading as publications cited refer to their use of yuccas in the general sense, rather than *Hesperoyucca* specifically. There is little doubt that indigenous peoples that had access to *H. newberryi* either through direct harvest or via trade, used the plants in similar ways as other indigenous groups used *H. whipplei*.

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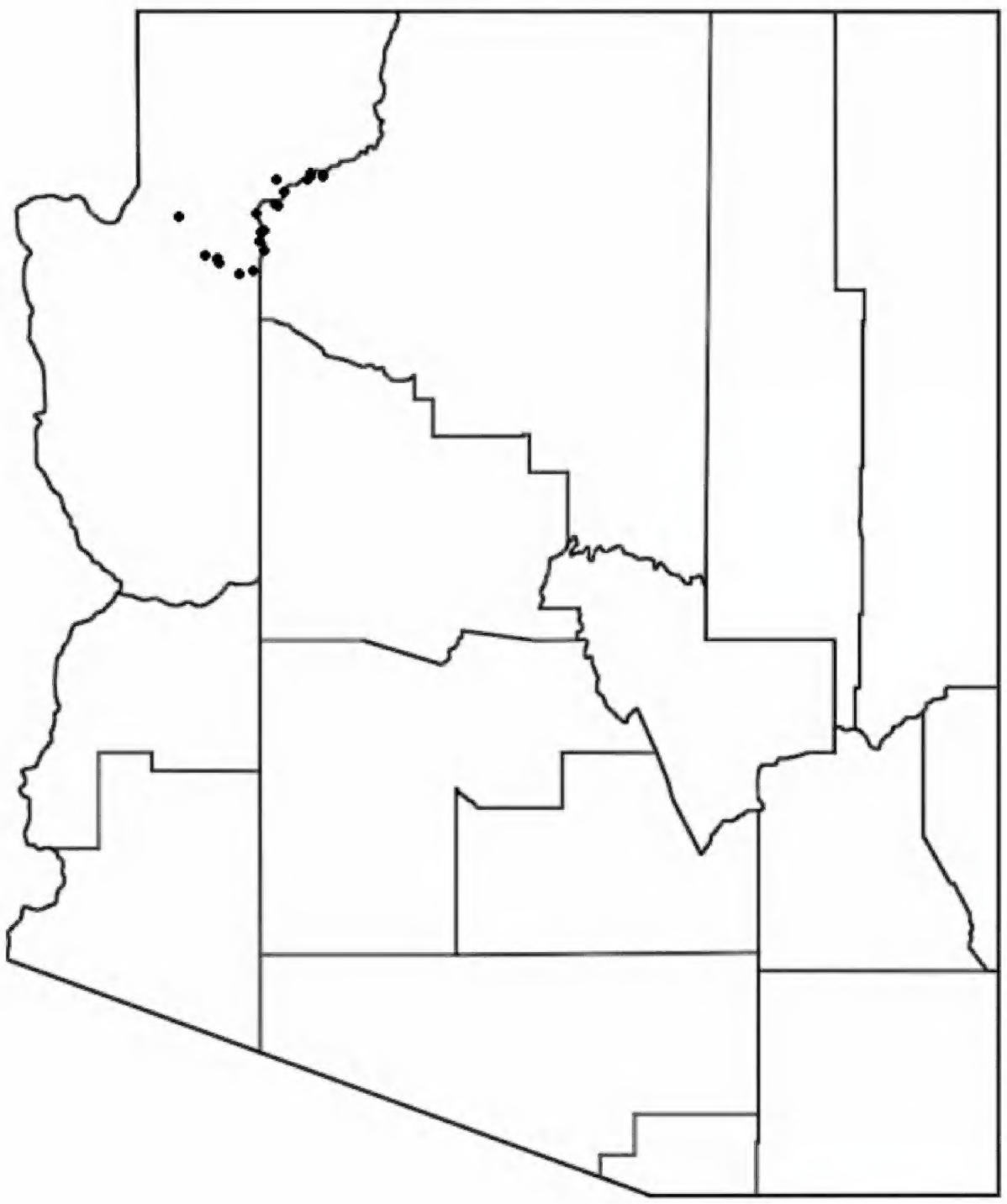
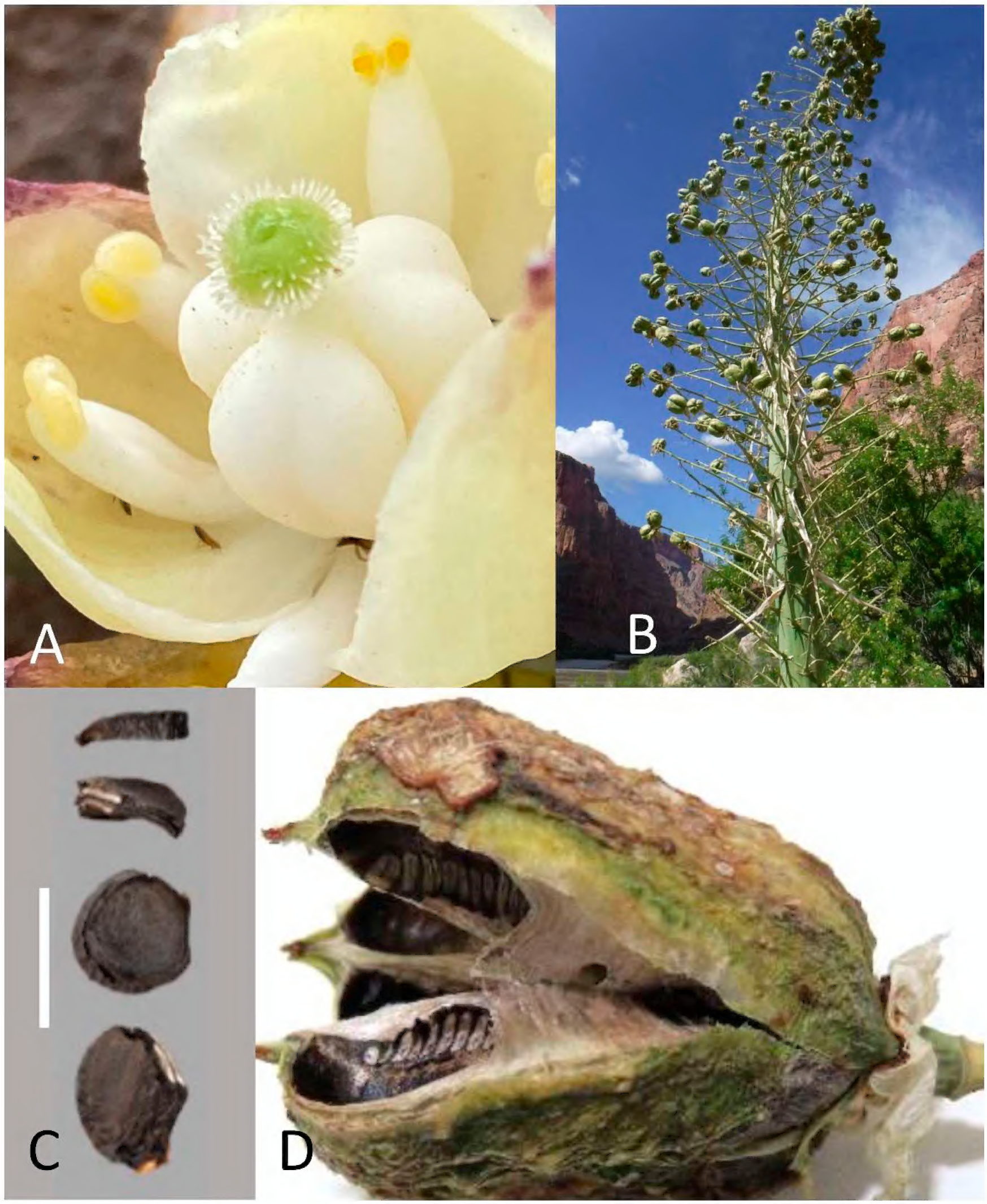


Agavaceae part 2: *Hesperoyucca.* Figure 1. Distribution of *H. newberryi* in Arizona.

Agavaceae part 2: *Hesperoyucca.* Figure 2. *H. newberryi*. A. Rosette as it appears before the flower stalk bolts, the photo taken on March 16, 2019. B. Same plant in flower 33 days later, April 18, 2019 (*Hodgson 32002 et al.*, DES). C. Inflorescence (*Hodgson 32002 et al.,* DES). D. Habit with fruiting stalk (*Hodgson 32060 et al.*, DES). Photos credits: A-C. Wendy Hodgson; D. Carrie Cannon.



Agavaceae part 2: *Hesperoyucca.* Figure 3. *H. newberryi*. A. Close-up of the flower showing the stamens and the ovary with the capitate and fringed stigma (*Hodgson 24578 et al.,* DES). B. Infructescence (*Hodgson 32060 et al.* DES). C. Seeds (*Hodgson et al. 32073,* DES; scale bar 1 cm). D. Mature fruit with inconspicuous placental wings (*Hodgson 32072 et al.,* DES). Photos credits: A, B, D. Wendy Hodgson; C. Michael Fickes.

Agavaceae part 2: *Hesperoyucca.* Figure 4. *H. newberryi*. A. Typical habitat of steep, rocky slopes with most individuals appearing to occur on north- or northeast facing slopes. The flowering individuals are often few and far between; note the arrow pointing to a person next to a plant in the background. B. Although its uses are not well documented, leaf fibers soaked in water form a soapy liquid and can be braided. C. Vincent Diaz washing his hair wth soapy water from leaves soaked in water. Photos by Wendy Hodgson.